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TECHNICAL PROGRESS REPORT FOR THE MONTH OF FEBRUARY 1964
LUNAR RESEARCH PROGRAM
CONTRACT NO. NASw-593

PREPARED FOR:
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TECHNICAL REPORT FOR THE MONTH OF FEBRUARY 1964

PART I - OBSERVATIONS

A. Accomplishments During the Month of January 1964

A total of sixteen days were suitable for observation during the month of February. The January data, which was not included in the report for that month, and the February data are attached. The data is presented in a form, though different from that used in previous reports, should be self-explanatory.

Five regions on the lunar surface have been chosen to illustrate the data to date.

They are:

1. The mountainous region in the southwest quadrant, covering roughly 5° east longitude to 20° west longitude, and 0° latitude to 40° south latitude.
2. The region in the southeast quadrant, containing the maria Nubium and Humorum, extending from about 5° east longitude to 40° east longitude, and from 5° south latitude to 30° south latitude.
3. The region containing the craters Copernicus and Kepler, extending from 0° latitude to about 20° north latitude, and from 10° east longitude to about 40° east longitude.
4. The region of Mare Imbrium, extending from 5° west longitude to 30° east longitude, and from about 20° north latitude to 50° north latitude.
5. The region in central west and northwest quadrant, containing the maria Serenitatis and Tranquillitatis, extending somewhat diagonally across the region between 5° west longitude to 40° west longitude, and 0° latitude to 40° north latitude.

The antenna temperatures for each region, corrected for atmospheric attenuation by the procedure described in the Monthly Progress Report for January 1964, are shown in the

attached figures. The horizontal bars on the data points indicate the approximate range of phase angles averaged over one beamwidth.

B. Program for the Month of March 1964

1. Lunar observations will continue.
2. The density of data points is becoming so large that it is difficult now to plot some of them as individual points. Beginning with the cumulative data through March 1964, data points for the month will be found by averaging all points in each 20 degree phase angle increment. This method will give 18 points per lunation, each with a measure of the dispersion found from the averaging procedure.

ANTENNA TEMPERATURE - DEGREES KELVIN

REGION OF MAIN SENSITIVITIES AND TRANQUILITIES

10

80

60

40

20

20

40

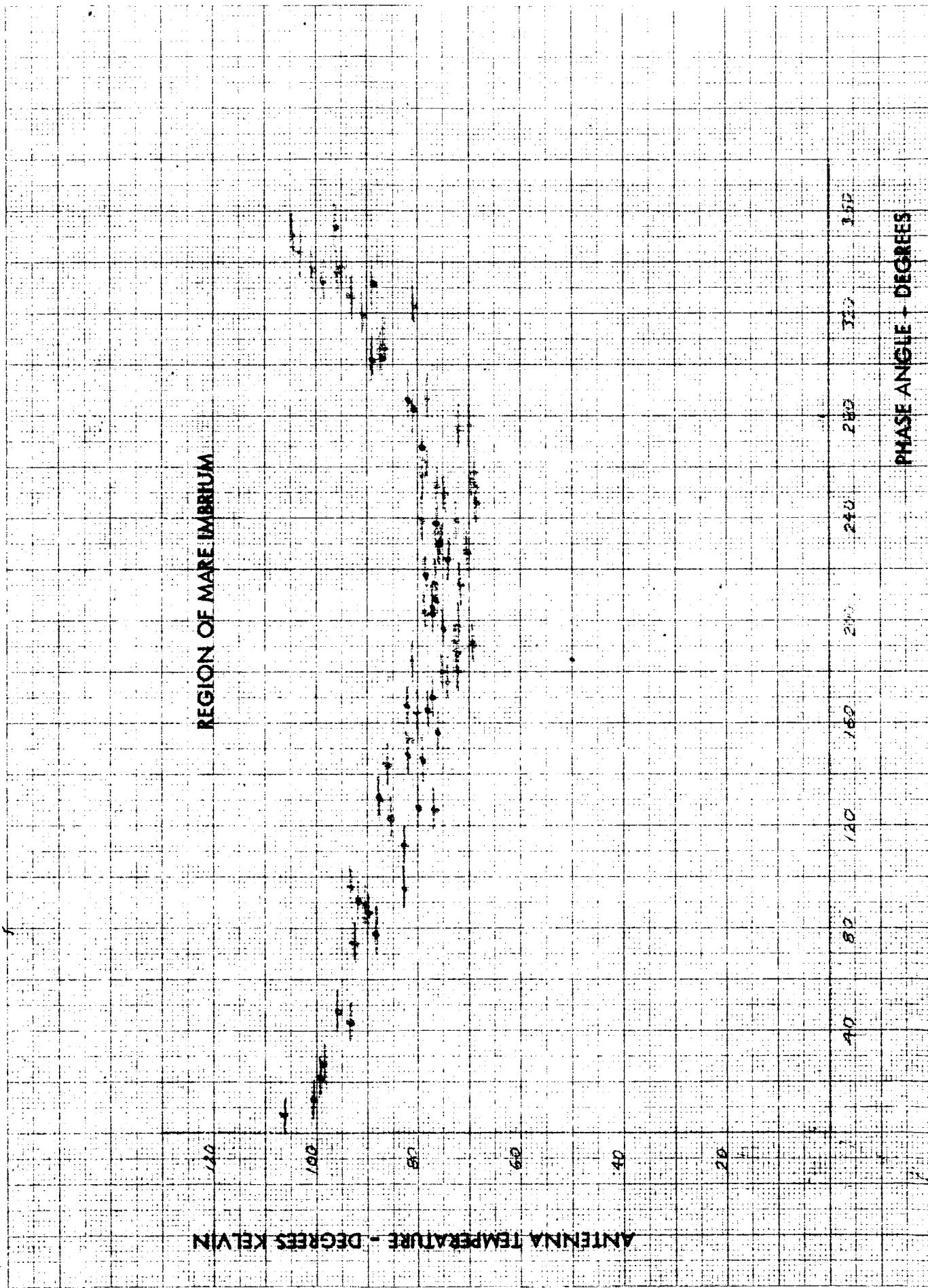
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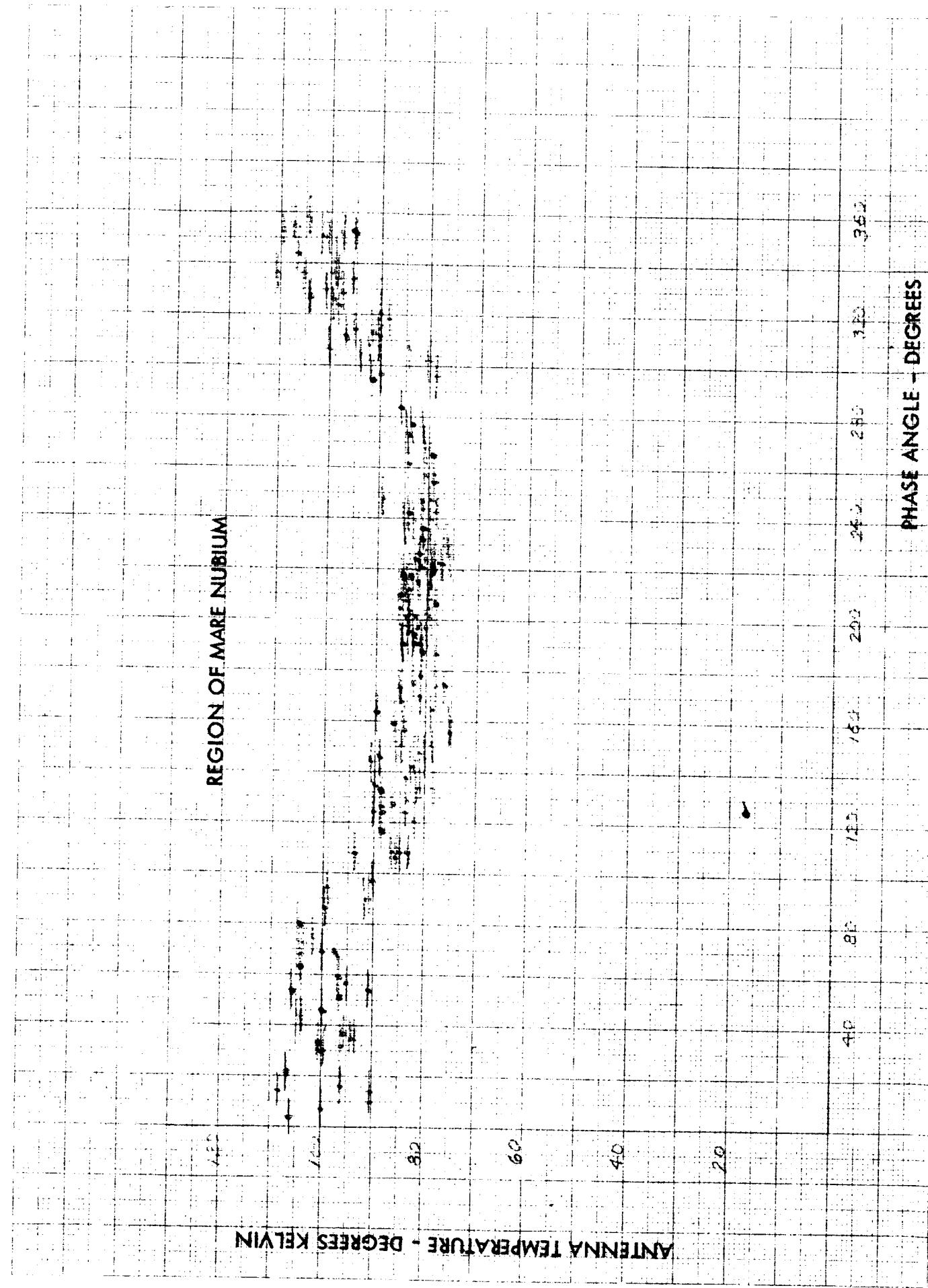
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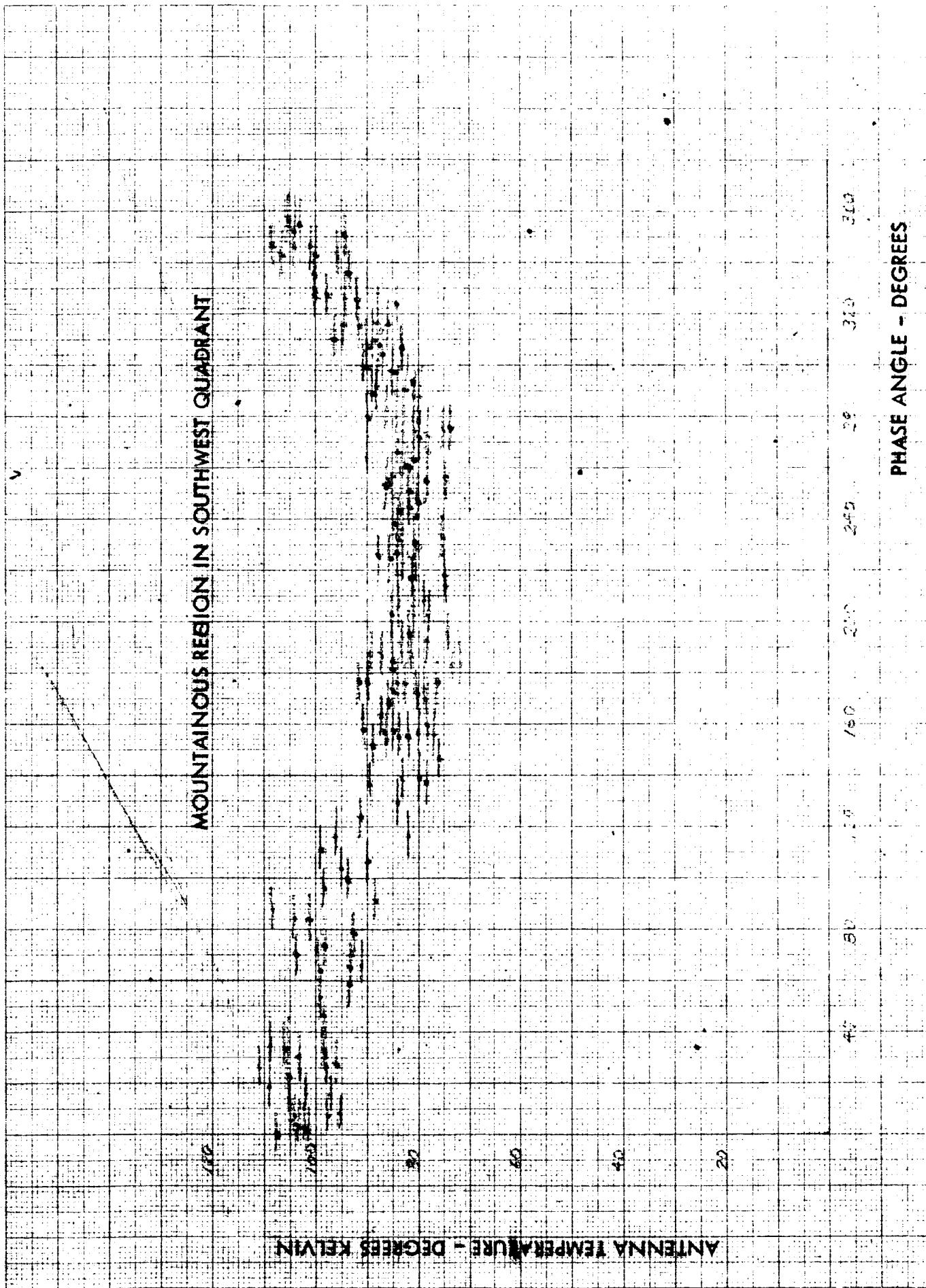
PHASE ANGLE - DEGREES





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ANTENNA TEMPERATURE-DEGREES KELVIN

REGION OF COPERNICUS AND KEPLER

62

40

22

62

40

22

40

20

10

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2

1

PHASE ANGLE - DEGREES

5

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OBSERVATIONS OF THE LUNAR ECLIPSE OF DECEMBER 31, 1964 AT
8.6 MM WAVELENGTH
ADDENDUM I TO PART I

1.0 INTRODUCTION

The eclipse was not very suitable for microwave observations. The circumstances were such that both penumbral and umbral phases occurred when the elevation angles of the moon were small. The disadvantages of low elevation angles are:

1. The moon sets before any sensible cooling at microwave frequencies can be observed.
2. Corrections for atmospheric attenuation become very large and therefore should be known accurately.
3. The usual plane earth assumption that leads to the $e^{-\tau \sec \Theta}$ correction becomes questionable at small elevation angles.
4. The antenna pointing errors are not known at large hour angles.

The major effects of the above considerations on the observations were:

1. The moon must be pointed radiometrically before each observation.
2. Data points should be gathered as rapidly as possible since little time is available for observation.

2.0 OBJECTIVE OF OBSERVATIONAL PROGRAM

The objective of the observational program was to obtain drift scans through the subterrestrial point beginning some time prior to the penumbral phase and continuing until moonset. Each drift curve would be accompanied by a calibrate signal.

As a control experiment, observations would also be made the following day, December 31, 1963, using the identical procedure that was followed on the day of the eclipse.

3.0 OBSERVATIONAL PROCEDURE

Observations began one hour prior to the beginning the penumbral phase. A sequence of scans was initiated as follows:

1. The center of the lunar disk was located by the same procedure used for the regular lunar observations. (Reference: Technical Progress Report No. 7).
2. The antenna beam was positioned West of the moon.
3. After completion of the drift scan, a calibrate signal, nominally 100°K, was turned on for approximately 15 seconds.
4. Repeat 1 through 3.

The time between drift scans was approximately 15 minutes. The following information was recorded on the chart paper for each scan:

1. Eastern Standard Time
2. Hour Angle
3. Declination

A total of seventeen scans were made before sunset on December 30 and sixteen on December 31, 1963.

The data for each day was stored in appropriately marked tubular cardboard containers.

4.0 DATA REDUCTION

The data to be evaluated consisted of seventeen drift curves made on December 30, 1963 and sixteen on December 31, 1963. Each drift was accompanied by a nominal 100°K calibrate signal.

4.1 Objectives

The objective was to compare antenna temperatures as a function of time for the two days of observation in order to determine if any measurable decrease in temperature during the eclipse occurred. Antenna temperatures from several selected regions were to be considered.

All temperatures would be corrected for atmospheric attenuation, the effect of which would be considerable because of the small elevation angles involved.

5.0 DATA REDUCTION PROCEDURE

5.1 Lunar Areas Considered

Antenna temperatures were taken from the center of each drift curve and on each side of center halfway to the edges. These points, in terms of the lunar surface, correspond to the following regions:

1. The region containing the craters Copernicus and Kepler (30° east longitude)
2. The subterrestrial region
3. The region containing Mare Tranquillitatis (30° west longitude)

5.2 Antenna Temperatures

The antenna temperatures corresponding to the desired points on the drift curves were obtained by the following steps:

1. Smooth curves were drawn through each drift scan and straight lines through each calibrate signal. Changes in antenna temperature comparable in width to the antenna beamwidth were followed, where short term changes due to receiver fluctuations were averaged.

2. Points on the drift curve corresponding to the center and edges of the lunar disk were found by the same procedure followed in regular lunar data reduction procedure (Reference: Technical Progress Report No. 7). The location of points on the center and halfway to each edge were marked.
3. The height of these points and the calibrate signal above the baseline were measured in centimeters.
4. Antenna temperatures corresponding to the three points in question were calculated for each drift curve and tabulated.

5.3 Elevation Angles

The elevation angles at which each drift scan was made were calculated from:

$$\sin E = \sin \delta \sin \lambda + \cos \delta \cos \lambda \cos \phi$$

where:

E = elevation angle

λ = latitude of the radio observatory

δ = declination of the moon

ϕ = hour angle of the moon

5.4 Atmospheric Attenuation Corrections

In order to correct for atmospheric attenuation, the antenna temperatures on both days were increased by the factor $e^{-\tau \sec \Theta}$, where τ , the opacity was taken as 0.05, and Θ is the zenith angle for each measurement. The choice of 0.05 for the opacity was to be verified from how well the corrected antenna temperatures from the December 31 data remained constant.

Subsequently, it was discovered from the more recent literature that the atmospheric opacity at 8.5 millimeters wavelength should fluctuate significantly with the atmospheric

water vapor content. All antenna temperatures then recorrected using $\tau = 0.0276$ for oxygen and $\tau = 0.006 \text{ per gm/m}^3$ at the surface for water vapor. The total opacity is the sum of the two opacities with the contribution from water vapor calculated from the actual surface water vapor content at the time of observations.

From the values of outside temperature and relative humidity, the absolute humidity was calculated as follows:

$$\rho = \frac{m_w P}{m RT} \quad (\text{RH})$$

where:

ρ = absolute humidity

m_w = molecular weight of water vapor

m = molecular weight of air

P = saturation vapor pressure

R = gas constant

T = temperature (absolute)

(RH) = relative humidity

The saturation pressure at the desired temperature is found from standard meteorological tables or charts.

The opacities were found to be 0.039 for December 30 and 0.043 for December 31. Recorrection of the antenna temperatures gave results that were no different from those obtained using $\tau = 0.05$ within the error of measurement.

6.0 REDUCED DATA

The reduced data for December 30 is shown in the table below.

Scan	E deg.	December 30					exp. 0.039 sec Θ	Corrected Antenna Temperature			
		Uncorrected Antenna Temperature			1	2		1	2	3	
		1	2	3							
1	48	102	105	95			1.048	107	110	99	
2	43	105	107	95			1.059	111	113	101	
3	40	103	113	95			1.064	109	120	101	
4	36	107	105	95			1.069	114	112	101	
5	33	100	102	90			1.075	107	110	97	
6	30	103	102	92			1.082	111	110	99	
7	25	108	102	91			1.093	109	111	99	
8	24	100	102	90			1.101	110	112	99	
9	21	100	103	92			1.114	111	115	102	
10	18	97	95	85			1.134	110	108	96	
11	16	95	91	87			1.154	110	105	100	
12	14	93	90	82			1.174	109	106	96	
13	11	92	90	80			1.245	114	112	100	
14	9	80	82	75			1.290	103	106	97	
15	7	80	79	69			1.396	112	110	96	
16	5	66	63	55			1.610	106	101	88	
17	2	36	36	34			2.890	104	104	98	

The temperatures are in degrees Kelvin, E is the elevation angle and Θ is the zenith angle. The numerals 1, 2, and 3 refer to the areas at 30° west longitude, subterrestrial region, and 30° east longitude, respectively.

The reduced data for the day following the eclipse, December 31, 1963, is shown below. The notation is the same as in the preceding table.

December 31

Scan	E deg.	Uncorrected Antenna Temperature			exp 0.043 sec Θ	Corrected Antenna Temperature		
		1	2	3		1	2	3
1	40	102	105	97	1.069	109	112	104
2	37	102	105	95	1.074	109	113	102
3	35	102	105	97	1.078	110	113	104
4	33	102	105	95	1.084	110	114	103
5	31	102	105	95	1.087	111	114	103
6	27	98	102	92	1.098	108	112	101
7	25	100	102	92	1.110	111	113	102
8	23	103	105	95	1.119	115	117	106
9	20	100	100	92	1.134	113	113	104
10	17	100	103	89	1.154	115	119	103
11	15	95	100	87	1.177	112	118	102
12	13	90	92	82	1.213	109	116	99
13	11	87	90	82	1.264	110	114	104
14	9	82	85	74	1.316	108	112	97
15	7	72	75	70	1.443	104	108	101
16	5	61	61	56	1.688	103	103	94

7.0 ANALYSIS AND CONCLUSIONS

The temperatures tabulated in the preceding section are shown as a function of elevation angle in the attached figures.

As can be seen, the antenna temperatures behave the same, within experimental error, for both days of observation. There is, therefore, no detectable decrease in

temperature at 8.6 MM wavelength for all three regions observed. These results are in agreement with lunation measurements; any temperature decline, if detectable, would not be expected to occur until after moonset for this longitude.

DECEMBER 30

1967 10:37:44.0Z S 21° 21'

ANTENNA TEMPERATURE - DEGREES KELVIN

100

80

60

40

20

0

ELEVATION ANGLE - DEGREES

50

30

15

0

15

30

45

60

DEC 17 1934

SUBTELESTORAL READING

200

100

50

30

40

20

ANTENNA TEMPERATURE - DEGREES KELVIN

ELEVATION ANGLE - DEGREES

55
50
45
40
35
30
25
20
15
10
5

52
46
40
35
30
25
20
15
10
5

ANTENNA TEMPERATURE - DEGREES KELVIN

DEC 17 1965 30

ELEVATION ANGLE - DEGREES

ANTENNA TEMPERATURE - DEGREES KELVIN

ELEVATION ANGLE - DEGREES

5 10 15 20 25 30 35 40 45 50

20

40

60

80

100

120

140 160 180

200 220 240

260 280 300

320 340 360

380 400 420

440 460 480

500 520 540

560 580 600

620 640 660

680 700 720

740 760 780

800 820 840

860 880 900

920 940 960

980 1000 1020

1040 1060 1080

1100 1120 1140

1160 1180 1200

1240 1260 1280

1300 1320 1340

1360 1380 1400

1440 1460 1480

1500 1520 1540

1560 1580 1600

1640 1660 1680

1700 1720 1740

1760 1780 1800

1840 1860 1880

1920 1940 1960

1980 2000 2020

2040 2060 2080

2120 2140 2160

2200 2220 2240

2280 2300 2320

2360 2380 2400

2440 2460 2480

2500 2520 2540

2560 2580 2600

2640 2660 2680

2700 2720 2740

2760 2780 2800

2840 2860 2880

2920 2940 2960

2980 3000 3020

3040 3060 3080

3120 3140 3160

3200 3220 3240

3280 3300 3320

3360 3380 3400

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3500 3520 3540

3560 3580 3600

3640 3660 3680

3700 3720 3740

3760 3780 3800

3840 3860 3880

3920 3940 3960

3980 4000 4020

4040 4060 4080

4120 4140 4160

4180 4200 4220

4240 4260 4280

4320 4340 4360

4400 4420 4440

4480 4500 4520

4560 4580 4600

4640 4660 4680

4720 4740 4760

4800 4820 4840

4920 4940 4960

5000 5020 5040

5120 5140 5160

5200 5220 5240

5320 5340 5360

5400 5420 5440

5520 5540 5560

5600 5620 5640

5720 5740 5760

5800 5820 5840

5920 5940 5960

6000 6020 6040

6120 6140 6160

6200 6220 6240

6320 6340 6360

6400 6420 6440

6520 6540 6560

6600 6620 6640

6720 6740 6760

6800 6820 6840

6920 6940 6960

7000 7020 7040

7120 7140 7160

7200 7220 7240

7320 7340 7360

7400 7420 7440

7520 7540 7560

7600 7620 7640

7720 7740 7760

7800 7820 7840

7920 7940 7960

8000 8020 8040

8120 8140 8160

8200 8220 8240

8320 8340 8360

8400 8420 8440

8520 8540 8560

8600 8620 8640

8720 8740 8760

8800 8820 8840

8920 8940 8960

9000 9020 9040

9120 9140 9160

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9320 9340 9360

9400 9420 9440

9520 9540 9560

9600 9620 9640

9720 9740 9760

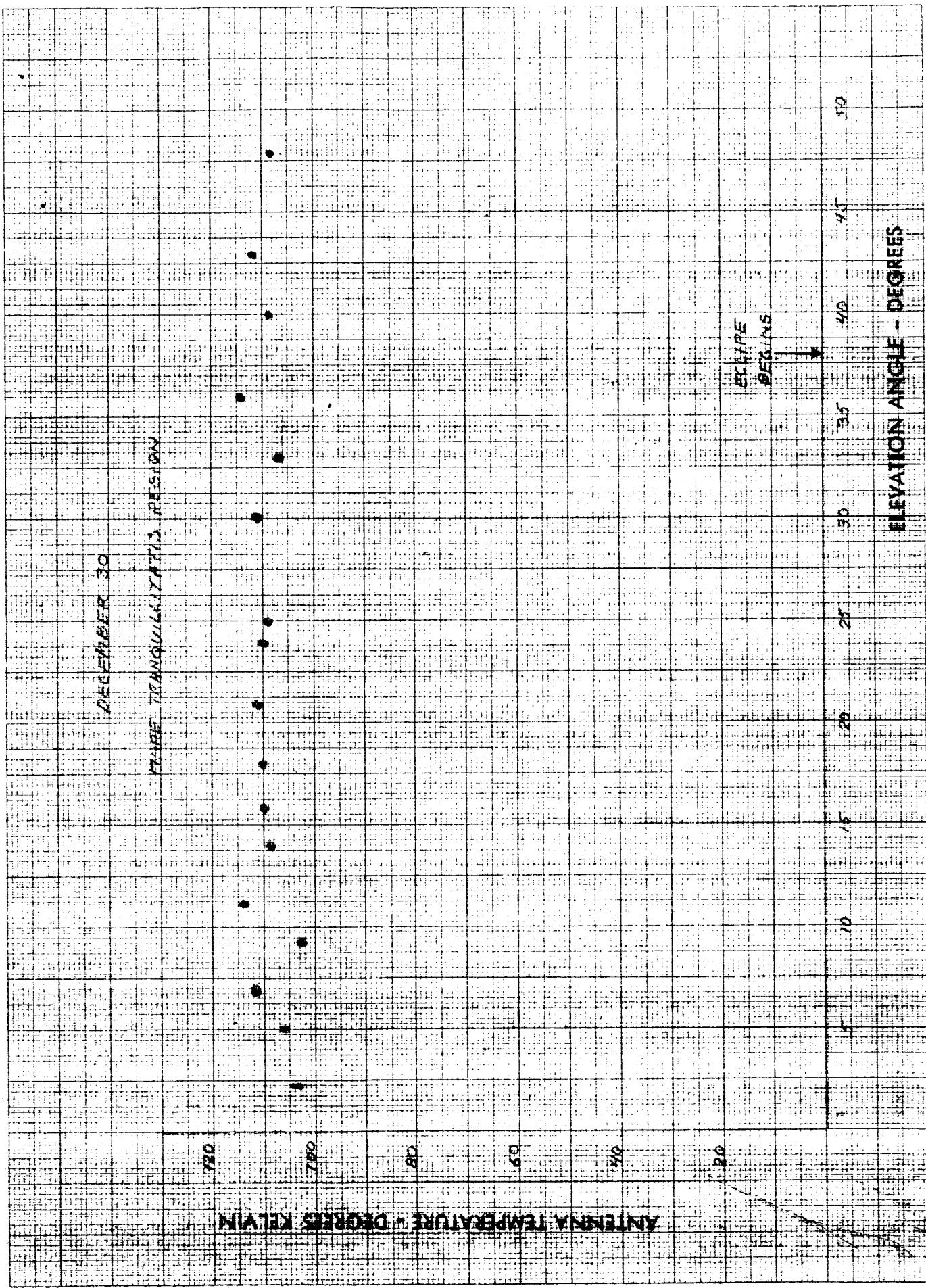
9800 9820 9840

9920 9940 9960

10000 10020 10040

ANTENNA TEMPERATURE - DEGREES KELVIN

ANTENNA TEMPERATURE - DEGREES CELSIUS



ELEVATION ANGLE - DEGREES

50 45 40 35 30 25 20 15 10 5

2A

4A

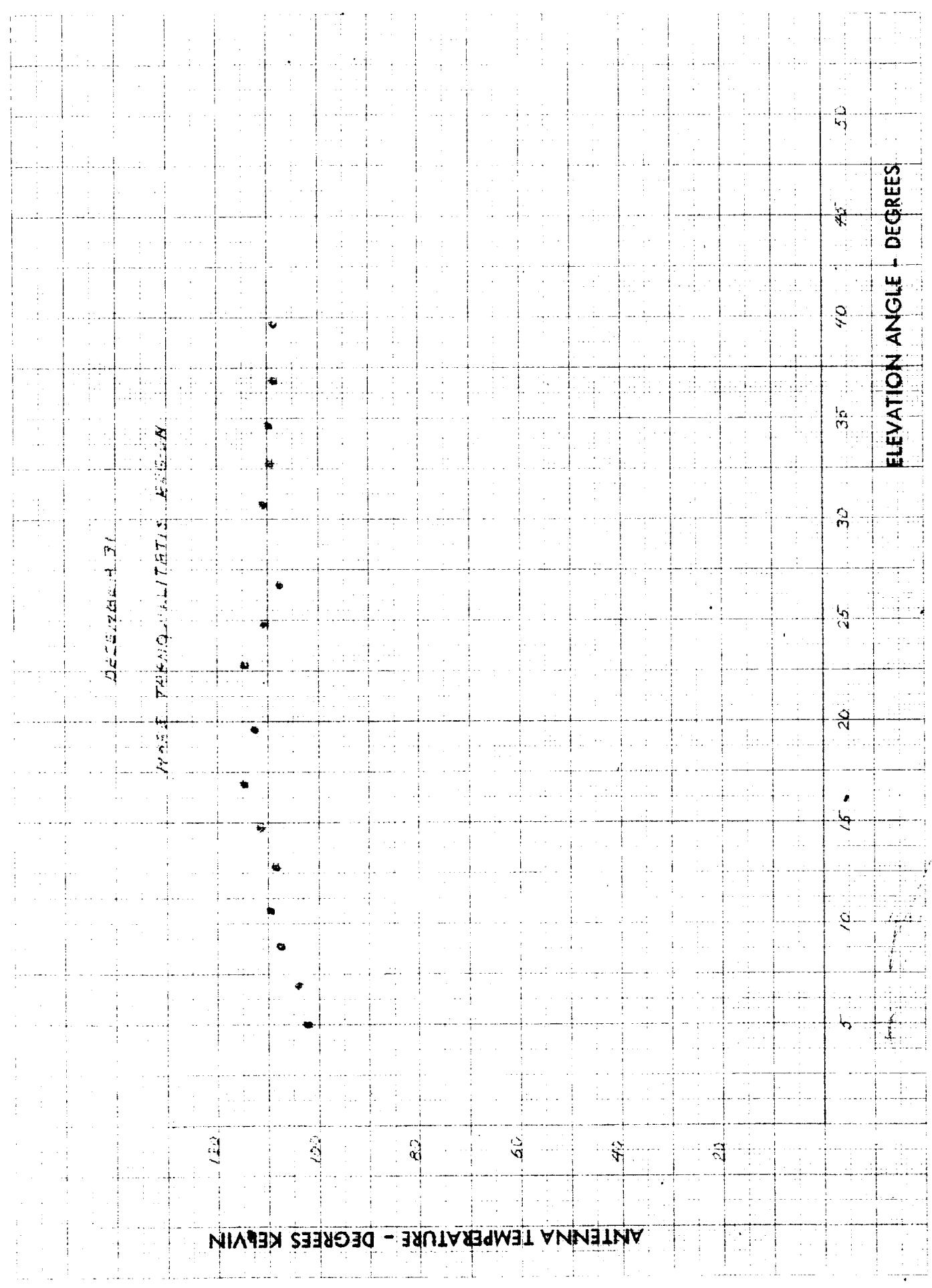
6A

8A

ANTENNA TEMPERATURE - DEGREES KEVIN

45° 30° 15° 0° -15° -30° -45°

Decreased 2%



PART II - THEORETICAL MODEL STUDIES

A. ACCOMPLISHMENTS DURING THE MONTH OF FEBRUARY, 1964

The primary effort during the month of February was in the preparation for programming of the theoretical microwave eclipse model, which will be used for comparison with the Aerospace Corporation 93 Gc microwave data referred to in the January Monthly Report.

In addition to the theoretical effort referred to above, further contacts have been made with leading infrared and radio experimenters who have in the past concentrated a significant portion of their efforts toward lunar research. These contacts were made with Saari and Shorthill of the Boeing Scientific Research Laboratory and Sinton of Lowell Observatory. The data taken by Saari and Shorthill of Boeing and Sinton of the Lowell Observatory during the total phase of the eclipse of December 30th, has questionable value due to adverse weather conditions. However, the principle investigator has been invited to visit their laboratories for a more thorough review of the data previously obtained and, in addition, a discussion of future data requirements from the theoretical point of view.

B. PROGRAM FOR THE MONTH OF MARCH, 1964

A trip during the latter portion of March to both Lowell Observatory and the Boeing Scientific Research Laboratory is planned for the discussion of current and future infrared observing programs for the moon. In addition, the theoretical work referred to above will continue as planned.

PART III - INVESTIGATION OF INSTRUMENT PARAMETERS

A. ACCOMPLISHMENTS DURING THE MONTH OF FEBRUARY 1964

The Part III portion of the Lunar Research Program is concentrating attention in the following areas:

Measurement of Instrument Parameters

Investigation of Techniques of Observations

Investigation of Atmospheric Effects

Efforts during the month of February were directed primarily to:

Continuation of Solar Patrol Observations to determine
antenna pointing errors.

Theoretical investigation of atmospheric effects.

Design and fabrication of equipments required to carry
out instrument measurements.

As indicated in the previous monthly report, it was anticipated that the approach to solar observations would be revised to accommodate the technique described in Addendum I to Part III of the January Report. This was not accomplished in view of the fact that certain additional graphical material and training was required before initiating the effort. In view of the excellent observing conditions during February, the observer normally assigned to this portion of the effort was made available to the Part I effort (Lunar Observations) to assist in the data reduction of a large amount of material that had been accumulated. Minor changes in the solar observing program initiated in mid-December were introduced to allow for appropriate correction of data. Solar observations carried out between December 15 and March 1, initiated under the direction of Warren Tyler, will be reduced and be presented as the subject of a separate addendum to his portion of the next monthly report.

Our investigation of the theoretical aspects of atmospheric effects and methods for data correction was completed during the month of February. A report on this subject prepared by Paul Kalaghan is included here as Addendum I.

Design and fabrication of auxiliary equipments for instrument measurements was initiated in the areas of:

Hohlraum

Video channel

Noise calibration sequence timer

Though the original intent was to provide a hohlraum for the feed system which could be placed in position over the feed by remote control, it was determined that the complexity of such an arrangement was not warranted at this time, in light of the number of measurements required in this mode of operation. We therefore designed a hohlraum configuration which will be placed in position over the feed manually. The results of initial tests will indicate whether or not the need remains for incorporating a remote form of operation.

The utilization of a hohlraum for these tests is somewhat unusual for calibration of the radiometric system, since its prime function is to terminate the input to the radiometer in a matched load at room temperature. This is normally achieved by the introduction of a waveguide switch which connects the input of the receiver either to the antenna output terminal or to a matched load. The hohlraum is necessitated by the fact that we have elected not to disturb the present radiometer feed configuration, since this would negate the large amount of data already accumulated on antenna pointing errors.

We currently anticipate installing the more conventional mode of waveguide switch operation for input termination of the radiometer at a later date, determined primarily by the availability of the beacon transmitter at Blue Hills, which will afford

the opportunity to quickly verify the antenna pointing position. Determination of antenna pointing error without a beacon is a rather involved process requiring solar and lunar observations to provide even a fixed position pointing error. Additional solar observations will, of course, be required even with the availability of the Blue Hills Transmitter, since by this technique we determine the general form of pedestal position and drive errors. Fortunately, much of this type of information has already been accumulated and is being expanded as a result of the Solar Observing Program. Once this information is completely available, we will be able to make immediate dial corrections for any modification in feed position, through one radio boresight measurement of antenna position, on the Blue Hills Transmitter.

Design was completed and fabrication initiated on a separate parallel video channel to provide longer integration times than available with the current receiving system. Here again, as in the case of the hohlraum for the feed system, the approach was carefully reviewed to assure that there would be no interference with the present receiving system by the introduction of the parallel channel. Our prime objective in the introduction of this auxiliary circuit is that it not modify or change in any way the present d.c. and integration output circuit of the receiving system, which provides a balanced input to the Sanborn Recorder. Our design approach to the parallel channel configuration is based on introducing the balanced output from the present receiver into a Philbrick (P_2) amplifier whose output then feeds a "gain compensated" integrator. The output of the variable time constant gain compensated integrator feeds the d.c. signal to the 5 meg ohm input of the Sanborn Recorder. A nominal gain of 1.5 is required for the Philbrick amplifier. This gain is adjusted to assure nominal unity gain, from the balanced output of the present receiving system to the recorder input, i.e., the gain of the Philbrick will offset the loss of the gain compensated integrator to meet the unity gain requirement. Fabrication of this unit has been initiated. Installation at the Observatory is scheduled for early March.

The third item scheduled for design and fabrication during the month of February, was a sequence timer to provide automatic operation of the noise calibration signal at the input to the radiometer, during unattended periods of operation. The first parameter of interest which will be measured, using this automatic sequencer, will be the gain stability of the radiometer during prolonged periods of operation as opposed to a period of a few hours following turn-on. The sequence timer has been designed and provides an "off" time adjustable over a period of 0 - 10 minutes and an "on" time adjustable over 0 - 120 seconds. The output of the sequence timer feeds a d.c. signal to the noise tube control circuit. This timing signal initiates an automatic pulse circuit which provides repetitive ignition signals to the gas tube, until firing is achieved. When the tube has been fired by the automatic pulse circuit, feedback of tube current shuts off the automatic pulser. Removal of the d.c. signal to the gas tube control circuit by action of the sequence timer, shuts off the gas tube.

Design of the sequence timer has been completed. Fabrication has been initiated and installation at the Observatory is anticipated early in March.

During the Month of February several approaches to the design of the beacon transmitter for Blue Hills were considered and preliminary discussions on this subject initiated with Professor Goody of the Blue Hills Observatory. As a result of our study we recognize that this field installation could quite possibly involve a substantial investment if the design is not approached in simple steps. We have decided to initiate a design which involves the absolute minimum of hardware in the first configuration and through actual operation determine the degree to which additional controls may be deemed advisable. The design is based on the following considerations:

1. Little or no temperature or frequency control for the klystron.
2. The klystron parabolic antenna and feed system will be installed in a light metal frame box open at one end.

3. The open end (transmitting end) will be covered with a thin sheet of Mylar.
4. The open end of the box will be tapered with respect to the vertical plane to minimize the effect of water accumulation on the Mylar sheet, under rainy conditions.

No provision will be made at this time for remote control of the transmitter from the Observatory. Initial tests will be carried out by locating an operator at Blue Hills. Frequency stability under changes in environmental temperature are the principal area of concern. Our first approach to overcoming this difficulty will be an attempt to "track" the Blue Hills oscillator with the receiver at the Observatory, based on knowledge of the internal transmitter box temperature at Blue Hills.

This approach will provide us immediate information on the efficacy of the Blue Hills transmitter technique, particularly in regard to a preliminary determination of antenna patterns. Determination of what additional temperature and remote control circuits may be desirable will be based on operating history.

B. PROGRAM FOR THE MONTH OF MARCH 1964

1. Installation of the hohlraum, video channel and noise calibration sequence timer at the Observatory.
2. Accumulation of preliminary test data on radiometer gain stability with input terminated, when operated for relatively short versus prolonged periods of time.
3. Accumulation of data to establish the comparative sensitivity and baseline stability of the radiometric system for various integration time constants, longer than those now achievable with the present system.

4. The report on solar observations during the period from December 16 through March 1 describing methods of approach, format of data presentation, methods of analysis and conclusions will be included as an Addendum to Part III of the March Report.
5. Preliminary fabrication of the beacon transmitter for installation at Blue Hills was initiated during the month of February, through procurement of long-lead items. The design layout for installation at Blue Hills will be completed in March and fabrication of this unit should be approximately 50% complete.

ADDENDUM I TO PART III

1.0 Theoretical Considerations

The physical and chemical properties of the atmosphere vary significantly with altitude. Convenient starting points toward the development of the expressions and relationships necessary to evolve tables of values descriptive of the earth's atmosphere are the Ideal Gas Laws and the Hydrostatic Equation.

The equation of state of an ideal gas is:

$$\rho = \frac{MP}{RT} \quad (1)$$

Where P is the atmospheric pressure, ρ is the air density, R is the universal gas constant, T is the absolute temperature, and M is the molecular weight of the gas. As would be expected, all of the above quantities vary with height, Z, except R. It may be noted that M, the mean molecular weight of air, is assumed to be constant up to an altitude of 90 km, while above this altitude M varies because of increasing dissociation and diffusive separation.

Assuming that the atmosphere is static with respect to the earth, the hydrostatic equation may be written:

$$dP = -\rho g dZ$$

where P, ρ , and Z are as defined and g is the acceleration due to gravity. Strictly speaking Z, the geometric altitude, is defined as the distance measured along a gravitational line of force from the zero equipotential gravitational surface to the point in question. However, the differences between this definition of Z and the straight line distance is negligible for the heights of interest here.

As a final parameter of significance in describing the atmosphere consider the geopotential altitude H defined as:

$$H = \int_0^Z \frac{g}{g_0} dZ$$

or

$$dH = \frac{g}{g_0} dZ$$

where g_0 is the sea level value of the gravitational acceleration. Physically, H corresponds to a distance measured along a line of force, but also weighted by the value of the gravitational field at each point. With this definition, the hydrostatic equation simplifies to:

$$dP = -\rho g_0 dH$$

2.0 Measurement Data⁽¹⁾

Up to $Z = 90$ km the molecular weight M is taken as constant at 28.9644 and is obtained from the perfect gas law and the sea level values of temperature, pressure, and density. Above 90 km because of molecular dissociation and diffusive separation, M decreases as shown in Figure 1.

The molecular-scale temperature, T_M , is defined by:

$$T_M = \frac{M_0}{M} T$$

This quantity is of importance since the determination of the atmospheric temperature T at great altitudes using conventional measurement techniques, requires a knowledge of the molecular weight M of the air at that altitude. Without a knowledge of M, the measurements yield only the ratio T/M. Because of the uncertainties in the value of M, rocket temperature measurements are confined to T/M without great loss since T/M also plays a fundamental role in the ideal gas law when pressure and density are desired. Since $M/M_0 = 1$ at all altitudes up to 90 km, we have $T_M = T$ in this region. Above 90 km due to the variation in M, T will generally be less than the molecular scale temperature T_M which is what is actually measured. Figures 2 and 3 illustrate the altitude dependence of T and T_M .

Within an atmospheric layer throughout which T_M is a linear function of H, the hydrostatic equation and perfect gas law yield:

$$\frac{P}{P_0} = \left[\frac{T_{M,0}}{(T_{M,0} + \alpha h)} \right]^{\frac{g_0 M_0}{R \alpha}} \quad \alpha \neq 0$$

and

$$\frac{P}{P_0} = \exp \left(-\frac{g_0 M_0 h}{R T_{M,0}} \right) \quad \alpha = 0$$

where α is the rate of change of molecular scale temperature with geopotential altitude, i.e.,

$$\alpha = \frac{dT_M}{dH}$$

and

$$h = H - H_0$$

Using the values of T_M obtained from rocket data, etc., the altitude dependence of the pressure is as shown in Figure 4.

As an additional variable, the atmospheric density ρ can be calculated from the pressure P and the molecular scale temperature T_M by the perfect gas law

$$\rho = \frac{M_0}{R} \frac{P}{T_M}$$

The resulting variation of ρ with altitude Z is illustrated in Figure 5. These temperature, density, and pressure profiles can now be used in determining the attenuation throughout a vertical path through the atmosphere once the density, pressure, and temperature dependence of the absorption coefficients are specifically defined.

3.0 Atmospheric Absorption

Using the model given above to describe the physical configuration of the atmosphere, it remains to examine the particular constituents giving use to the absorption process. For a frequency of 35 kmc, these constituents causing energy absorption are water vapor and molecular oxygen.

3.1 Water Vapor Absorption

The water molecule has an asymmetric top structure whose electric dipole moment couples with the incident electromagnetic field to produce rotational lines from a frequency of 22 Gc to frequencies well into the infrared region of the spectrum. Collision broadening is important enough to cause the skirts of many of these lines to yield significant attenuation at 35 Gc even though it is well removed from the 22 Gc line itself.⁽¹⁰⁾

Using the Van Vleck equation, the water vapor absorption coefficient, $\gamma(\nu)$, for incident energy at a frequency ν due to a resonance at frequency ν_0 is:

$$\gamma(\nu) = \alpha \nu^2 \frac{\rho}{T} \left(\frac{\Delta\nu}{(\nu_0 - \nu)^2 + (\Delta\nu)^2} + \frac{\Delta\nu}{(\nu + \nu_0)^2 + (\Delta\nu)^2} \right)$$

where

$$\alpha = 3.3 \times 10^{22} (\log_{10} e) \frac{8\pi^2 \mu^2}{3 G k c} e^{-\frac{E}{kT}}$$

$\Delta\nu$ = line width parameter

ν_0 = H₂O molecular resonance frequency

ν = incident frequency

k = Boltzmann constant

G = molecular partition function $1092 e^{-545/T}$ for T around 293°K

μ^2 = "effective" dipole measurement after weighting by nuclear spin and line strength terms

E = energy of initial state

ρ = water vapor density

King, Hainer, and Cross have calculated the line strengths for all possible transitions for H₂O from J = 1 to J = 6. Energy levels, calculated by Dennison, are given by Van Vleck for the same range in J. The largest uncertainty, however, is in the line width, $\Delta\nu$, with Tolbert, Bond and Coates recommending a value of 6 Gc although this value is not altogether satisfactory either.⁽⁴⁾⁽⁵⁾⁽⁶⁾

In order to arrive at a zenith attenuation, $\gamma(\nu)$ above must be integrated along a vertical path through the atmosphere characterized by the pressure and temperature profiles

contained in Figures 2 and 4. This task is much simplified by the fact that $\gamma_{(2)}$ depends on the partial pressure due to water vapor above (not the total pressure) and this partial pressure drops off more rapidly with height than does the total pressure. Thus the integration need only be carried out to altitudes of 10 km for an average case.

This method tacitly assumes a knowledge of the exact height variation of the H_2O vapor at the time of observation. Usually this dependence is not known so that a ground level measurement together with the distribution from a Model Atmosphere must be employed in place of data such as would come from a true height profile measurement by means of a radiosonde.

(8) Barrett has indicated that an exponential variation with a scale height of 5 km is a good approximation to the average condition existing in the atmosphere in the Boston area. Using this type height variation in ρ and the temperature variation in Figure 2, the attenuation given in Figure 7 results as a function of the surface value of vapor density measured at the time of observation.

The determination of ground level water vapor density is done as follows: first, the ambient temperature and relative humidity are measured with normal thermometer and psychrometer. The temperature is used to determine the value (Figure 8) of the water vapor density in a saturated atmosphere at this temperature. The actual water vapor density is obtained by multiplying the saturated density value from Figure 8 by the relative humidity previously measured. The appropriate absorption is then obtained from Figure 7 for this value.

3.2 Molecular Oxygen Absorption

Oxygen is an electrically non-polar molecule and would not be expected to interact with microwave radiation. However, the molecule does exhibit a magnetic dipole moment. This magnetic moment is very weak in comparison with usually encountered electric dipole moments, but due to the high percentage of oxygen in air and the long transmission paths, this type absorption become appreciable.

From the Van Vleck derivation, the expression for the absorption coefficient $\gamma(\nu)$ for incident energy at frequency ν , due to resonances at frequency ν_J is

$$\gamma(\nu) = 2.67 \frac{P}{T^3} \nu^2 \sum_J S_J \exp(-E_J/kT)$$

where

$$S_J = F_{J+}\mu_{J+}^2 + F_{J-}\mu_{J-}^2 + F_o\mu_{J_0}^2$$

$$F_{J\pm} = \frac{\Delta\nu}{(\nu_{J\pm}-\nu)^2+(\Delta\nu)^2} + \frac{\Delta\nu}{(\nu_{J\pm}+\nu)^2+(\Delta\nu)^2}$$

$$F_o = \frac{\Delta\nu}{\nu^2+(\Delta\nu)^2}$$

$$\mu_{J+}^2 = \frac{J(2J+3)}{J+1}$$

$$\mu_{J-}^2 = \frac{(J+1)(2J-1)}{J}$$

$$\mu_{J_0}^2 = \frac{2(J^2+J+1)(2J+1)}{J(J+1)}$$

$$E_J/kT = 2.07 J(J+1)/T$$

where

P = partial pressure of molecular oxygen

T = temperature in ${}^\circ K$

ν = incident frequency

ν_J = resonance frequency of oxygen molecule

K = Boltzmann's Constant

E_J = energy of initial molecular state

J = total angular momentum quantum number

(The resonance frequencies ν_{J+} and ν_{J-} have been calculated for all transitions from $J=1$ to $J=45$ and are given in Meeks and Lilley.)

Since the above expression gives the attenuation through a 1 km portion of the atmosphere at temperature T and pressure P , the total zenith attenuation can only be obtained by integrating the $\gamma(\nu)$ expression over the temperature and pressure profile occurring along a vertical ray path.

The effect of the atmospheric model employed in integrating such an expression throughout the ray path can be seen by noting the strong pressure and temperature dependence expressed by the $(\frac{P}{T^3})$ factor in $\gamma(\nu)$. In addition, the line width parameter $\Delta\nu$ is also a function of pressure and temperature, although the exact dependence is, as with water vapor, still unknown. A reasonable approach to this problem is the empirical expression used by Lilley and Meeks which contains a linear pressure dependence, a $T^{-0.85}$ temperature dependence and an altitude dependent pressure broadening factor. The net result is a steadily decreasing line width parameter with a value of about 800 Mc at sea level, 10 Mc at 30 km, and 100 Kc at 80 km when an ARDC model atmosphere is assumed.

Utilizing this form of line width variation, the above Van Vleck type absorption coefficient, and the model atmosphere given, Meeks arrives at a zenith attenuation of 0.12 db. One fortunate aspect of this absorption is that it is relatively stable and does not vary with time of observation and local weather conditions as does the water vapor absorption.

3.3 Non-Vertical Ray Paths

It should be noted that all the above attenuations have been based on ray paths rising vertically through the atmosphere, i.e., with a 0° zenith angle. For zenith angles limited to less than 70° and assuming a horizontally stratified atmosphere, the variation in attenuation with zenith angle may be written:

$$\gamma(\theta) = \gamma(0) \sec \theta$$

where $\gamma(0)$ is the zenith value of the attenuation previously calculated.

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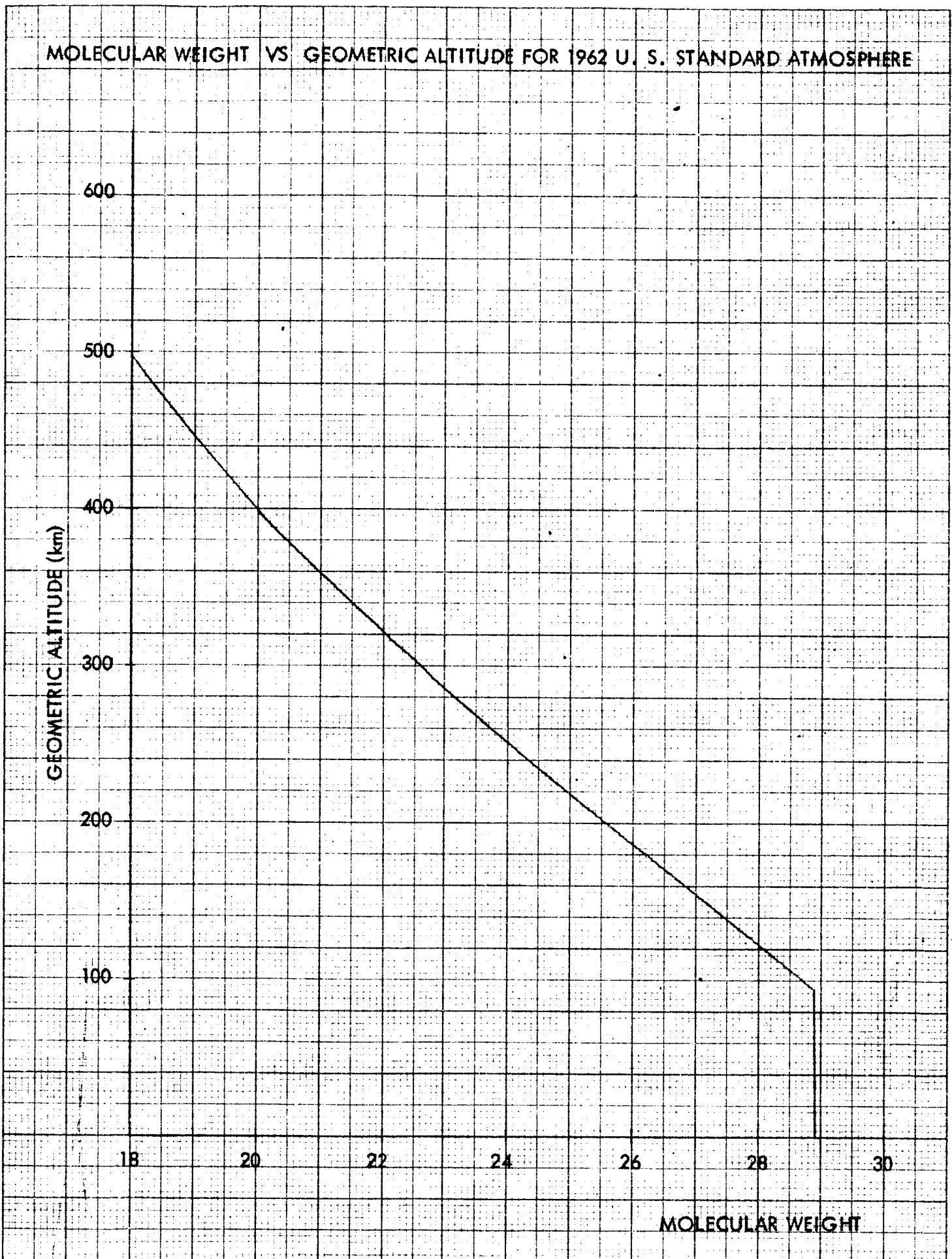


FIGURE 1

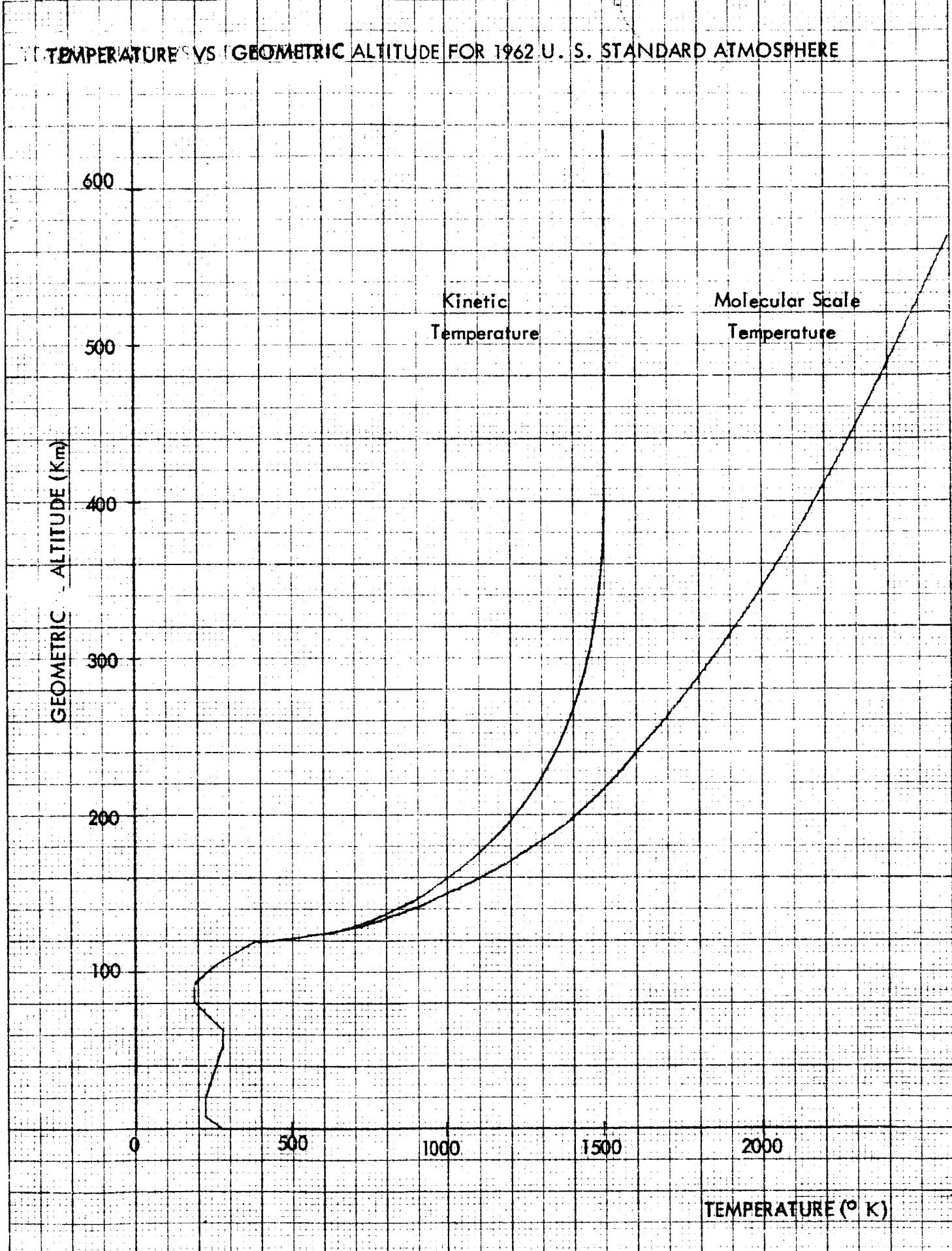


FIGURE 2

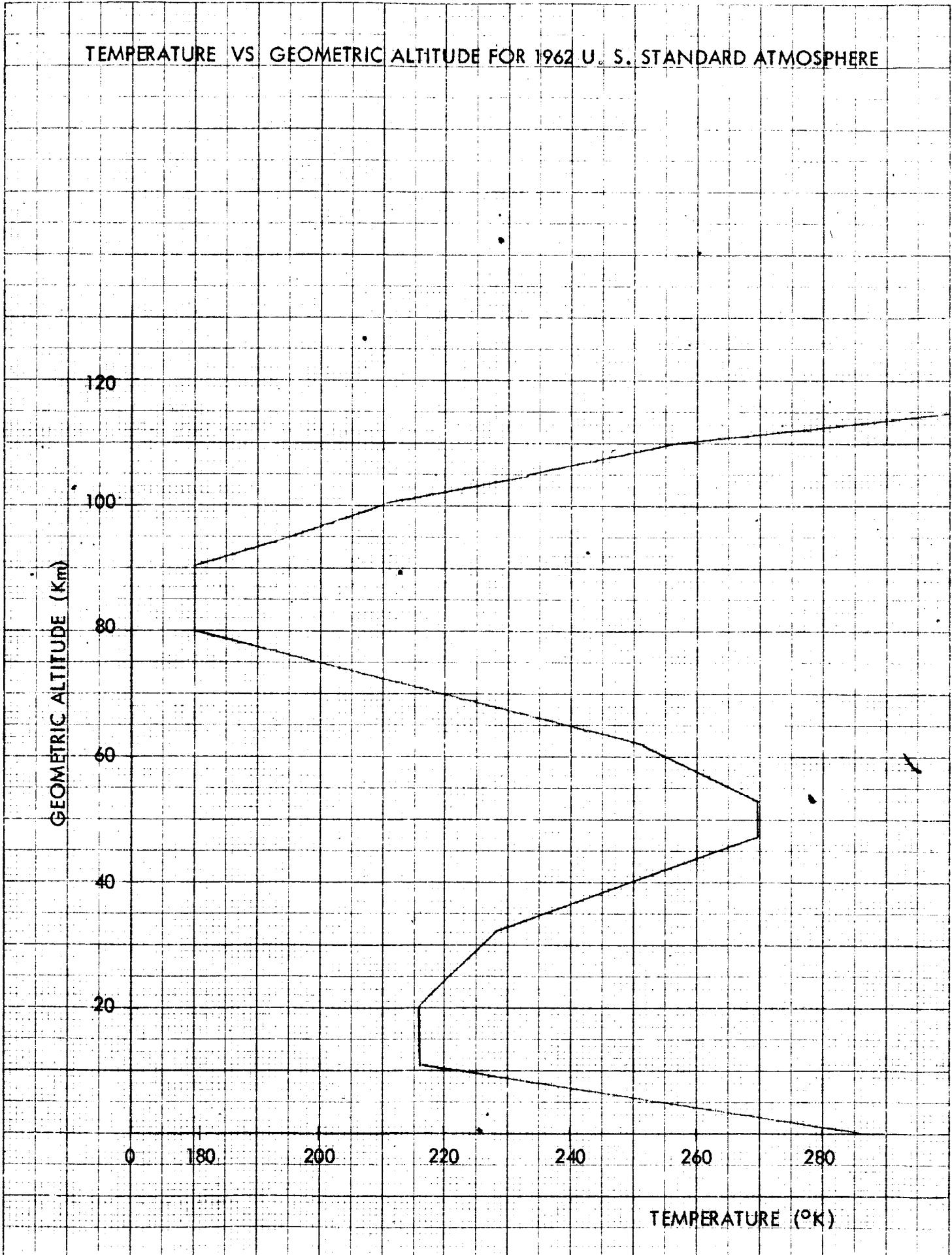


FIGURE 3

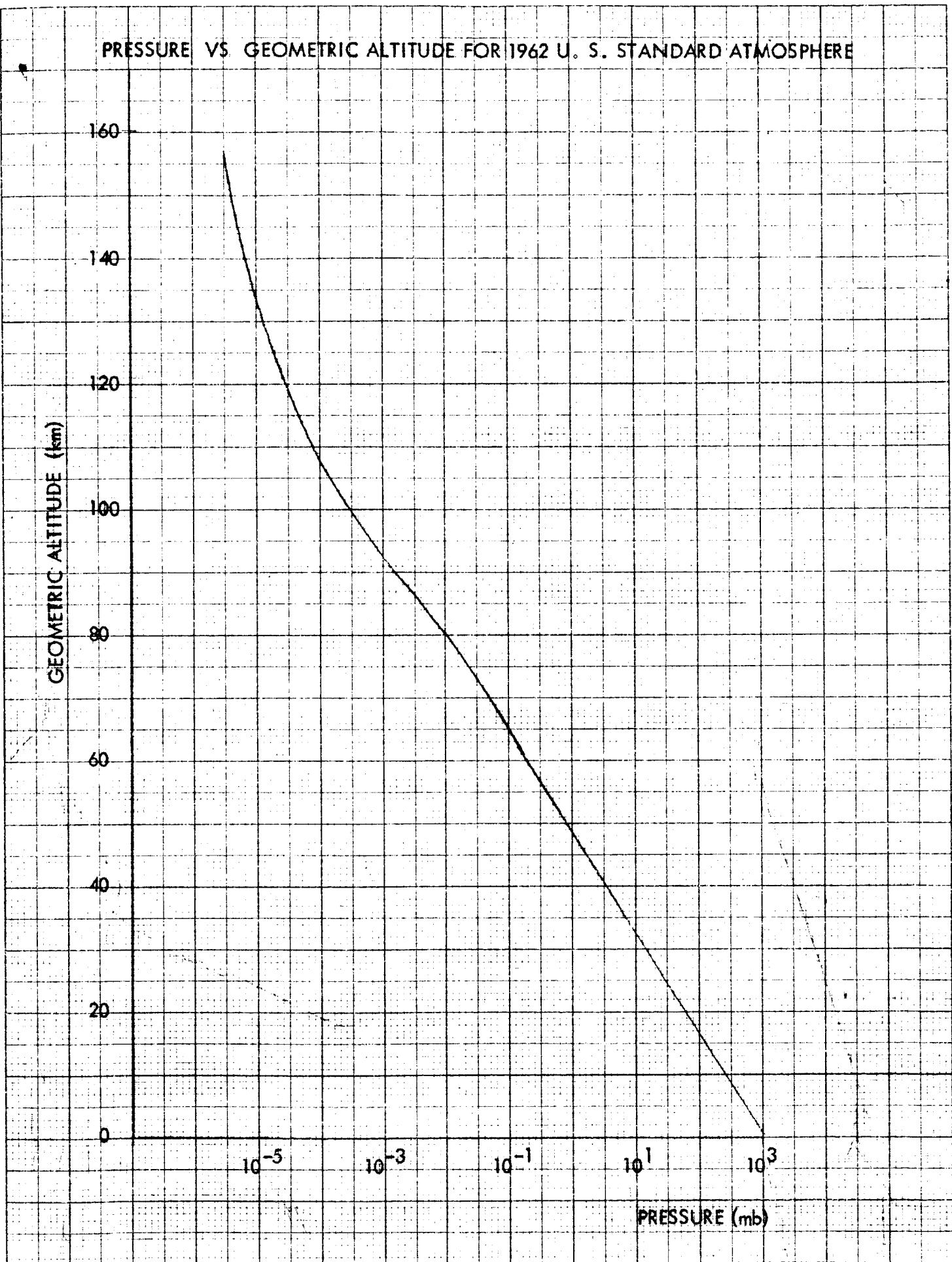


FIGURE 4

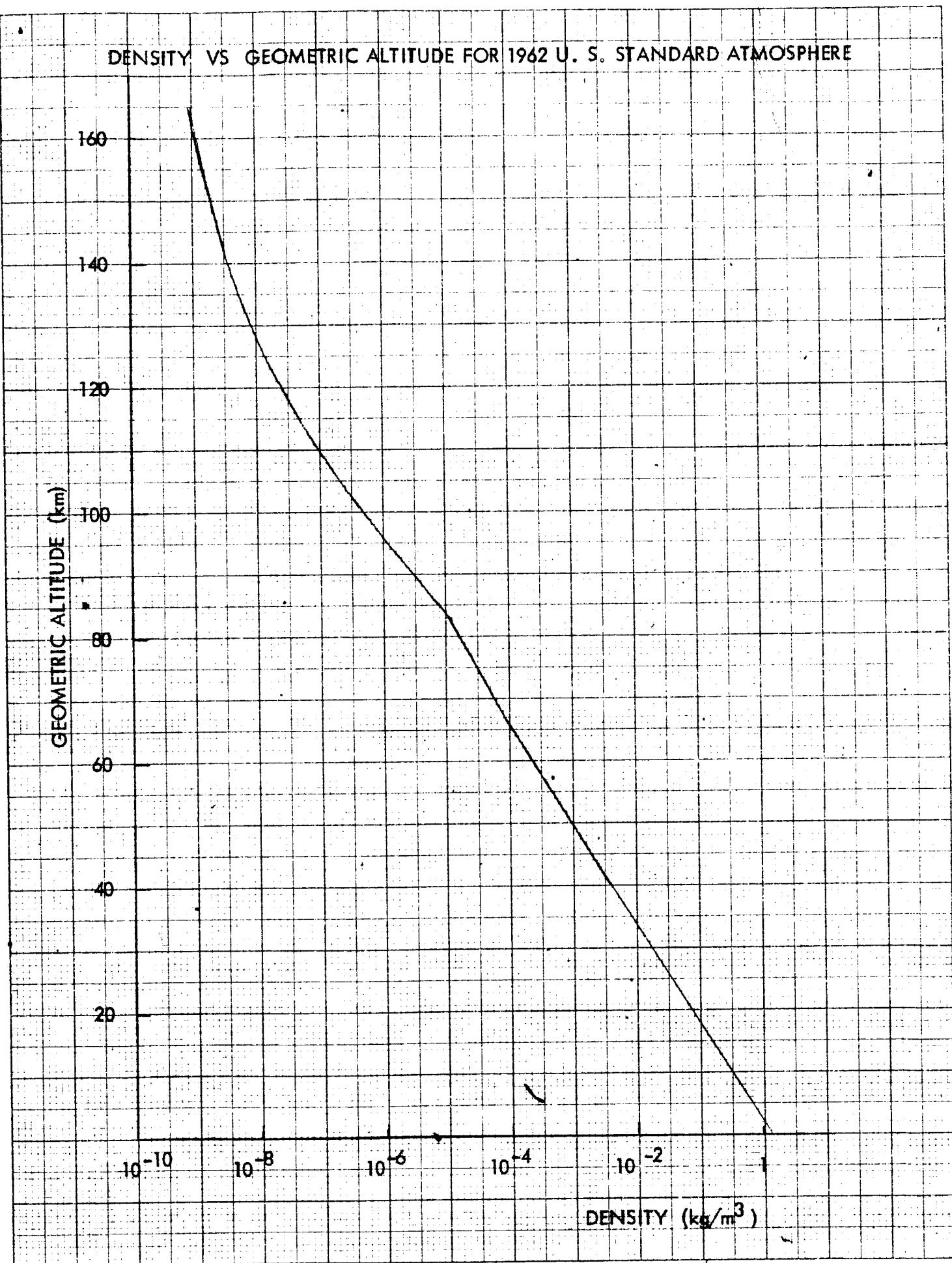


FIGURE 5

NORWOOD, MASSACHUSETTS.
THE CODEX BOOK COMPANY, INC.

CODEX BOOK COMPANY, INC.

NO. 154 12 DIVISIONS BY THREE 3-INCH CYCLES RATIO RULING.

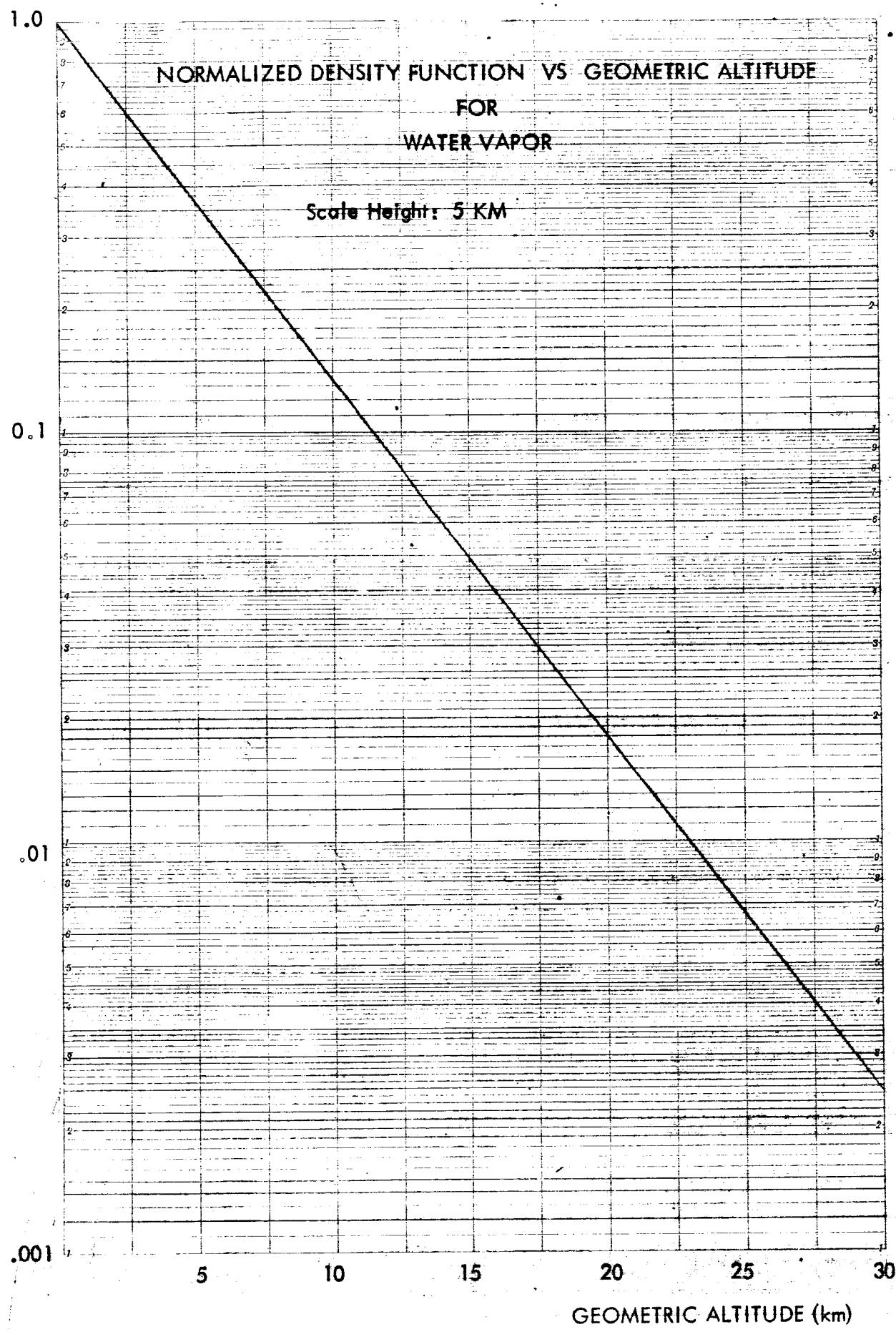


FIGURE 6

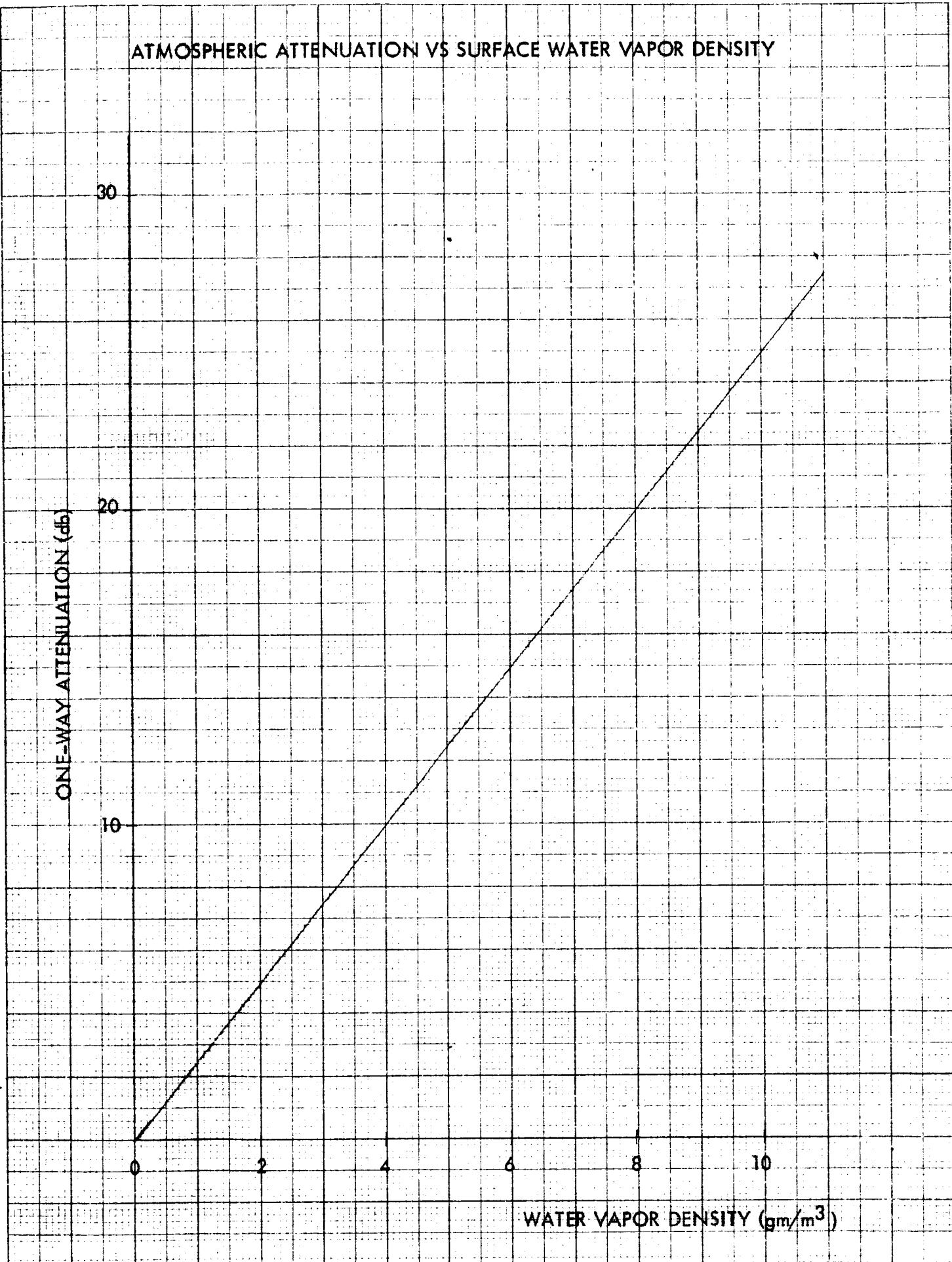


FIGURE 7

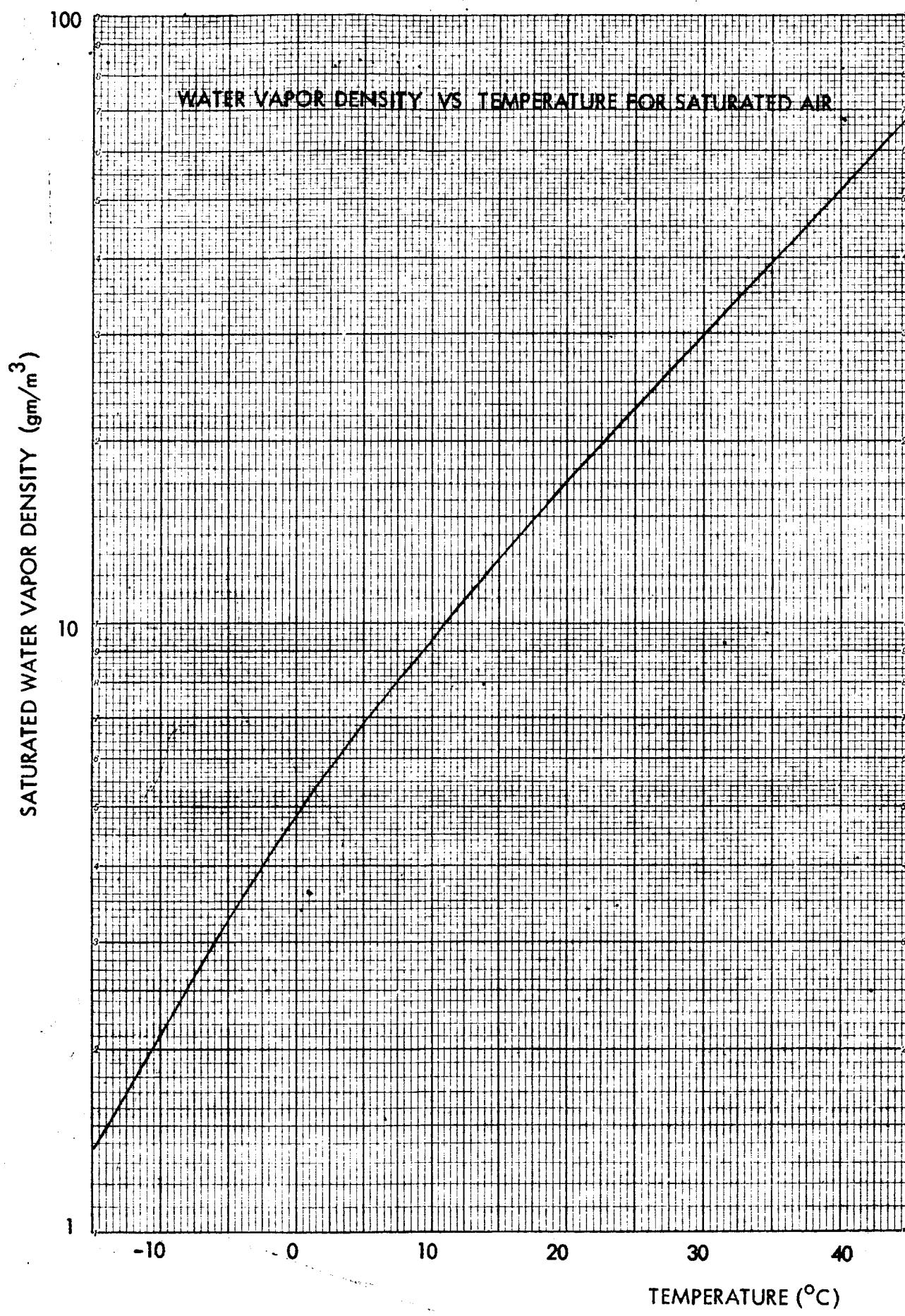


FIGURE 8

DAILY REPORT
LUNAR OBSERVING PROGRAM
CONTRACT NO. NASw-593

Date: January 11, 1964 Observers: Copeland

Time of Observation: Lunar Phase: 144°

From 0930 To 1100 Polar Axis Tilt Angle: 8°

Number of Scans: 7 Angular Size of Moon: $29' 34''$

Beginning and Ending RA: Weather Conditions: Clear

Beginning and Ending Declination: Temperature (outside): 28°

Beginning and Ending Hour Angle: Temperature (radome): 72°

Time of Meridional Crossing: 10:15 EST Relative Humidity: 33%

Solar Declination: $-21^{\circ} 59'$ Dew Point: -17° F

Solar Colongitude: 234° Declination of Center
(Dial Reading) $-20^{\circ} 24' 00''$

REMARKS

LUNAR OBSERVATIONAL DATA

Date: January 11, 1964

SCAN	A	B	C	D	E	F.	G
Antenna Temp.	64.7	69.5	68.5				
Phase Angle	260	134	109				
Latitude	-56	-53	-49				
Longitude	W 16	E 10	E 35				
Antenna Temp.	70.9	78.5	79.6	78.0	75.8		
Phase Angle	179	158	139	121	101		
Latitude	-37	-35	-32	-30	-27		
Longitude	W 35	W 14	E 05	E 23	E 43		
Antenna Temp.	67.4	79.3	84.7	86.8	86.8	86.3	77.1
Phase Angle	200	176	158	142	126	108	86
Latitude	-22	-20	-17	-15	-13	-11	- 9
Longitude	W 56	W 32	W 14	E 02	E 18	E 36	E 58
Antenna Temp.	73.5	82.0	85.8	89.6	90.1	89.0	83.6
Phase Angle	198	176	160	144	128	112	90
Latitude	-06	-05	-02	0	+02	+04	+07
Longitude	W 54	W 32	W 16	0	E 16	E 32	E 54
Antenna Temp.	74.1	83.3	87.7	89.9	88.8	85.6	82.2
Phase Angle	203	179	162	146	130	112	88
Latitude	+09	+12	+14	+16	+18	+20	+22
Longitude	W 59	W 35	W 18	W 02	E 14	E 32	E 56
Antenna Temp.	81.7	86.5	87.7	88.3	86.5		
Phase Angle	187	167	149	130	109		
Latitude	+27	+30	+33	+35	+38		
Longitude	W 43	W 23	W 05	E 14	E 35		
Antenna Temp.	87.4	90.6	90.6				
Phase Angle	179	154	126				
Latitude	+50	+53	+57				
Longitude	W 35	W 10	E 18				

DAILY REPORT
LUNAR OBSERVING PROGRAM
CONTRACT NO. NASw-593

Date: January 16, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 207°

From 1245 EST to 1415 EST

Polar Axis Tilt Angle: 343.4°

Number of Scans: 7

Angular Size of Moon: $30' 36''$

Beginning and Ending RA: $21^{\text{h}}23^{\text{m}}27^{\text{s}}$
 $21^{\text{h}}26^{\text{m}}44^{\text{s}}$

Weather Conditions: Clear but slight haze

Beginning and Ending Declination: $-18^\circ 35'01''$
 $-18^\circ 23'30''$

Temperature (outside): 38°

Beginning and Ending Hour Angle: E $00^{\text{h}}41^{\text{m}}56^{\text{s}}$
W $00^{\text{h}}44^{\text{m}}45^{\text{s}}$

Temperature (radome): 71°

Time of Meridional Crossing: 1330 EST

Relative Humidity: 50%

Solar Declination: $-21^\circ 09'25''$

Dew Point: 22°

Solar Colongitude: 297°

Declination of Center
(Dial Reading) $-18^\circ 40' 43''$

REMARKS

Declination error is $11' 26''$ South of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: January 16, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	72.6	72.5	68.6				
	Phase Angle	250	229	204				
	Latitude	-44	-50	-58				
	Longitude	W 43	W 22	E 03				
2	Antenna Temp.	77.1	82.3	82.3	79.4	76.8		
	Phase Angle	253	234	218	200	178		
	Latitude	-21	-26	-31	-36	-42		
	Longitude	W 46	W 27	W 11	E 07	E 29		
3	Antenna Temp.	72.5	80.1	84.4	84.5	83.4	81.1	75.8
	Phase Angle	266	244	227	211	196	178	153
	Latitude	-02	-06	-10	-15	-19	-24	-29
	Longitude	W 59	W 37	W 20	W 04	E 11	E 29	E 54
4	Antenna Temp.	72.6	79.3	84.7	86.7	85.7	82.7	77.2
	Phase Angle	260	239	222	207	192	175	154
	Latitude	+14	+09	+05	0	-05	-09	-14
	Longitude	W 53	W 32	W 15	0	E 15	E 32	E 53
5	Antenna Temp.	65.0	76.8	81.1	82.3	82.3	82.2	71.4
	Phase Angle	260	236	218	203	187	171	148
	Latitude	+29	+24	+20	+15	+11	+06	+02
	Longitude	W 53	W 29	W 11	E 04	E 20	E 36	E 59
6	Antenna Temp.	64.9	73.8	74.8	74.6	69.7		
	Phase Angle	236	214	196	180	161		
	Latitude	+43	+37	+31	+26	+21		
	Longitude	W 29	W 07	E 11	E 27	E 46		
7	Antenna Temp.	49.8	55.6	51.2				
	Phase Angle	210	186	164				
	Latitude	+58	+50	+44				
	Longitude	W 03	E 21	E 43				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date: January 17, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 219°

From 1330 EST to 1500 EST

Polar Axis Tilt Angle: 339.9°

Number of Scans: 7

Angular Size of Moon: $30' 52''$

Beginning and Ending RA: $22^{\text{h}} 17^{\text{m}} 12^{\text{s}}$
 $22^{\text{h}} 20^{\text{m}} 25^{\text{s}}$

Weather Conditions: Clear but hazy

Beginning and Ending Declination: $-14^{\circ} 57' 03''$
 $-14^{\circ} 42' 07''$

Temperature (outside): 35°

Beginning and Ending Hour Angle: E $00^{\text{h}} 46^{\text{m}} 14^{\text{s}}$
W $00^{\text{h}} 40^{\text{m}} 14^{\text{s}}$

Temperature (radome): 76°

Time of Meridional Crossing: 1415 EST

Relative Humidity: 54%

Solar Declination: $-20^{\circ} 58' 14''$

Dew Point: 21°

Solar Colongitude: 309°

Declination of Center
(Dial Reading) $-14^{\circ} 59' 51''$

REMARKS

Declination error is $10' 15''$ South of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: January 17, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	69.7	70.3	68.3				
	Phase Angle	264	244	223				
	Latitude	-42	-49	-58				
	Longitude	W 45	W 25	W 04				
2	Antenna Temp.	77.0	81.5	81.5	79.0	75.1		
	Phase Angle	266	248	231	214	193		
	Latitude	-18	-24	-30	-36	-44		
	Longitude	W 47	W 29	W 12	E 05	E 26		
3	Antenna Temp.	71.8	81.4	86.2	87.7	85.2	82.2	76.3
	Phase Angle	278	255	240	225	209	192	167
	Latitude	+02	-04	-09	-15	-20	-26	-32
	Longitude	W 59	W 36	W 21	W 06	E 10	E 27	E 52
4	Antenna Temp.	72.3	78.9	83.8	85.0	84.0	81.1	76.2
	Phase Angle	271	250	234	219	204	188	167
	Latitude	+16	+11	+05	0	-05	-11	-16
	Longitude	W 52	W 31	W 15	0	E 15	E 31	E 52
5	Antenna Temp.	67.1	76.6	81.8	84.1	82.7	79.0	68.5
	Phase Angle	271	246	229	214	199	183	161
	Latitude	+32	+26	+20	+15	+09	+04	-02
	Longitude	W 52	W 27	W 10	E 05	E 20	E 36	E 58
6	Antenna Temp.	68.5	74.2	77.1	76.3	73.3		
	Phase Angle	245	224	207	190	173		
	Latitude	+44	+37	+30	+25	+19		
	Longitude	W 26	W 05	E 12	E 29	E 46		
7	Antenna Temp.	54.9	61.1	57.7				
	Phase Angle	216	194	174				
	Latitude	+58	+49	+42				
	Longitude	E 03	E 25	E 45				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date: January 18, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 232°

From 1415 EST To 1545 EST

Polar Axis Tilt Angle: 337.4°

Number of Scans: 7

Angular Size of Moon: $31' 07''$

Beginning and Ending RA: $23^{\text{h}} 09^{\text{m}} 15^{\text{s}}$
 $23^{\text{h}} 12^{\text{m}} 56^{\text{s}}$

Weather Conditions: Broken overcast

Beginning and Ending Declination: $-10^{\circ} 29' 12''$
 $-10^{\circ} 11' 40''$

Temperature (outside): 39°

Beginning and Ending Hour Angle: E $00^{\text{h}} 49^{\text{m}} 55^{\text{s}}$
W $00^{\text{h}} 37^{\text{m}} 10^{\text{s}}$

Temperature (radome): 77°

Time of Meridional Crossing: 1500 EST

Relative Humidity: 67%

Solar Declination: $-20^{\circ} 46' 40''$

Dew Point: 29°

Solar Colongitude: 322°

Declination of Center
(Dial Reading) $-10^{\circ} 29' 35''$

REMARKS

Declination error is $9' 08''$ South of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: January 18, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	70.3	71.7	67.6				
	Phase Angle	279	260	240				
	Latitude	-39	-48	-58				
	Longitude	W 47	W 28	W 08				
2	Antenna Temp.	73.5	80.1	80.5	76.3	71.7		
	Phase Angle	279	262	246	229	208		
	Latitude	-17	-23	-30	-37	-45		
	Longitude	W 47	W 30	W 14	E 03	E 24		
3	Antenna Temp.	71.2	78.4	81.3	83.6	82.2	79.4	75.3
	Phase Angle	291	269	253	238	223	206	181
	Latitude	+04	-02	-08	-14	-21	-27	-35
	Longitude	W 59	W 37	W 21	W 06	E 09	E 26	E 51
4	Antenna Temp.	72.7	82.2	85.8	87.2	84.9	83.1	77.6
	Phase Angle	284	263	247	232	217	201	180
	Latitude	+18	+12	+06	0	-06	-12	-18
	Longitude	W 52	W 31	W 15	0	E 15	E 31	E 52
5	Antenna Temp.	67.1	76.7	83.6	85.8	84.4	81.7	76.3
	Phase Angle	283	258	241	226	211	195	173
	Latitude	+34	+27	+21	+14	+08	+03	-04
	Longitude	W 51	W 26	W 09	E 06	E 21	E 37	E 59
6	Antenna Temp.	69.2	77.5	78.0	76.0	73.3		
	Phase Angle	256	235	218	202	185		
	Latitude	+45	+37	+30	+23	+17		
	Longitude	W 24	W 03	E 14	E 30	E 47		
7	Antenna Temp.	64.0	67.8	65.0				
	Phase Angle	225	204	185				
	Latitude	+58	+48	+40				
	Longitude	E 07	E 28	E 47				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date: January 19, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 245°

From 1515 EST to 1645 EST

Polar Axis Tilt Angle: 336.2°

Number of Scans: 7

Angular Size of Moon: 31' 24"

Beginning and Ending RA: 0^h 02^m 07^s
 0^h 05^m 15^s

Weather Conditions: Sunny but hazy

Beginning and Ending Declination: -05° 21' 53"
 -05° 02' 36"

Temperature (outside): 45°

Beginning and Ending Hour Angle: E 00^h 39^m 06^s
 W 00^h 48^m 03^s

Temperature (radome): 75°

Time of Meridional Crossing: 1600 EST

Relative Humidity: 51%

Solar Declination: -20° 34' 42"

Dew Point: 28°

Solar Colongitude: 335°

Declination of Center
(Dial Reading) -5° 18' 23"

REMARKS

Declination error is 6' 07" south of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: January 19, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	73.3	70.5	66.2				
	Phase Angle	293	274	255				
	Latitude	-38	-47	-58				
	Longitude	W 48	W 29	W 10				
2	Antenna Temp.	81.0	82.9	83.5	80.0	76.1		
	Phase Angle	293	275	260	243	222		
	Latitude	-16	-22	-29	-37	-45		
	Longitude	W 48	W 30	W 15	E 02	E 23		
3	Antenna Temp.	71.7	79.5	83.9	86.4	83.9	80.0	75.1
	Phase Angle	304	282	266	252	237	220	195
	Latitude	+05	-01	-08	-14	-21	-28	-36
	Longitude	W 59	W 37	W 21	W 07	E 08	E 25	E 50
4	Antenna Temp.	72.6	81.5	85.1	88.1	86.0	81.6	74.1
	Phase Angle	296	275	259	245	231	215	194
	Latitude	+19	+13	+06	0	-06	-13	-19
	Longitude	W 51	W 30	W 14	0	E 14	E 30	E 51
5	Antenna Temp.	68.2	78.7	84.9	86.8	86.4	84.9	76.3
	Phase Angle	295	271	253	239	224	208	186
	Latitude	+36	+28	+21	+14	+08	+02	-05
	Longitude	W 50	W 26	W 08	E 06	E 21	E 37	E 59
6	Antenna Temp.	69.3	74.2	76.4	76.9	74.9		
	Phase Angle	267	247	230	215	197		
	Latitude	+45	+37	+30	+23	+16		
	Longitude	W 22	W 02	E 15	E 30	E 48		
7	Antenna Temp.	60.6	65.9	66.8				
	Phase Angle	236	216	197				
	Latitude	+58	+47	+39				
	Longitude	E 09	E 29	E 48				

DAILY REPORT
LUNAR OBSERVING PROGRAM
CONTRACT NO. NASw-593

Date: January 27, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 346°

From 2230 EST to 2400 EST

Polar Axis Tilt Angle: 5.7°

Number of Scans: 7

Angular Size of Moon: 32' 28"

Beginning and Ending RA: $7^{\text{h}} 54^{\text{m}} 13^{\text{s}}$
 $7^{\text{h}} 58^{\text{m}} 05^{\text{s}}$

Weather Conditions: Hazy sky

Beginning and Ending Declination: $+22^{\circ} 14' 55''$
 $+22^{\circ} 09' 13''$

Temperature (outside): 36°

Beginning and Ending Hour Angle: E $00^{\text{h}} 44^{\text{m}} 14^{\text{s}}$
W $00^{\text{h}} 42^{\text{m}} 12^{\text{s}}$

Temperature (radome): 79°

Time of Meridional Crossing: 2315EST

Relative Humidity: 46%

Solar Declination: -18° 45' 27"

Dew Point: 19°

Solar Colongitude: 76°

Declination of Center (Dial Reading)

REMARKS

Declination error is 13' 30" North of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: January 27, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	90.6	88.7	85.9				
	Phase Angle	05	338	312				
	Latitude	-56	-53	-50				
	Longitude	W 19	E 08	E 34				
2	Antenna Temp.	101	102	100	97.0	91.9		
	Phase Angle	23	01	342	324	304		
	Latitude	-36	-35	-33	-30	-28		
	Longitude	W 37	W 15	E 04	E 22	E 42		
3	Antenna Temp.	98.4	106	108	107	104	96.6	86.3
	Phase Angle	43	19	0	344	328	311	288
	Latitude	-21	-19	-17	-16	-14	-12	-10
	Longitude	W 57	W 33	W 14	E 02	E 18	E 35	E 58
4	Antenna Temp.	102	110	110	107	101	94.3	85.9
	Phase Angle	40	18	02	346	330	313	292
	Latitude	-6	-4	-2	0	+2	+4	+5
	Longitude	W 54	W 32	W 16	0	E 16	E 33	E 54
5	Antenna Temp.	96.6	106	109	107	102	94.6	83.2
	Phase Angle	44	21	04	348	330	314	290
	Latitude	+11	+13	+14	+15	+17	+19	+21
	Longitude	W 58	W 35	W 18	W 02	E 16	E 32	E 56
6	Antenna Temp.	90.1	95.0	92.1	88.4	79.9		
	Phase Angle	28	08	350	331	310		
	Latitude	+28	+30	+32	+35	+36		
	Longitude	W 42	W 22	W 04	E 15	E 36		
7	Antenna Temp.	64.5	68.7	59.4				
	Phase Angle	21	354	327				
	Latitude	+50	+53	+56				
	Longitude	W 35	W 08	E 19				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date: January 31, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 23°

From 0115 EST To 0245 EST

Polar Axis Tilt Angle: 22.78°

Number of Scans: 7

Angular Size of Moon: $31' 26''$ Beginning and Ending RA: $10^{\text{h}} 51^{\text{m}} 42^{\text{s}}$
 $10^{\text{h}} 54^{\text{m}} 55^{\text{s}}$

Weather Conditions: Clear

Beginning and Ending Declination: $+12^{\circ} 04' 44''$
 $+11^{\circ} 47' 44''$ Temperature (outside): 25° Beginning and Ending Hour Angle: E $00^{\text{h}} 43^{\text{m}} 18^{\text{s}}$
W $00^{\text{h}} 43^{\text{m}} 16^{\text{s}}$ Temperature (radome): 77°

Time of Meridional Crossing: 0200 EST

Relative Humidity: 62%

Solar Declination: $-17^{\circ} 42' 27''$ Dew Point: 15° Solar Colongitude: 113° Declination of Center
(Dial Reading) $+11^{\circ} 59' 52''$ REMARKSDeclination error is $3' 37''$ North of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: January 31, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	76.3	81.6	80.3				
	Phase Angle	15	355	335				
	Latitude	-58	-48	-39				
	Longitude	E 08	E 28	E 48				
2	Antenna Temp.	88.3	95.9	96.8	95.1	90.6		
	Phase Angle	47	26	09	353	336		
	Latitude	-45	-37	-30	-23	-17		
	Longitude	W 24	W 03	E 14	E 30	E 47		
3	Antenna Temp.	87.1	98.4	106	108	106	99.3	89.8
	Phase Angle	73	49	32	17	02	346	324
	Latitude	-35	-27	-21	-14	-08	-02	+04
	Longitude	W 50	W 26	W 09	E 06	E 21	E 37	E 59
4	Antenna Temp.	88.5	103	106	107	106	101	92.1
	Phase Angle	75	53	38	23	08	352	332
	Latitude	-18	-12	-06	0	+06	+12	+18
	Longitude	W 52	W 30	W 15	0	E 15	E 31	E 51
5	Antenna Temp.	91.2	103	108	110	105	98.4	90.3
	Phase Angle	82	60	44	29	14	357	333
	Latitude	-04	+02	+08	+15	+21	+27	+34
	Longitude	W 59	W 37	W 21	W 06	E 09	E 26	E 50
6	Antenna Temp.	96.6	102	102	98.8	92.0		
	Phase Angle	71	53	37	21	359		
	Latitude	+17	+23	+30	+37	+45		
	Longitude	W 48	W 30	W 14	E 02	E 24		
7	Antenna Temp.	91.3	87.6	84.8				
	Phase Angle	71	52	31				
	Latitude	+40	+48	+58				
	Longitude	W 48	W 29	W 08				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date: February 3, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 61°

From 0330 EST To 0500 EST

Polar Axis Tilt Angle: 22.4°

Number of Scans: 7

Angular Size of Moon: $30' 02''$ Beginning and Ending RA: $13^{\text{h}} 19^{\text{m}} 34^{\text{s}}$
 $13^{\text{h}} 22^{\text{m}} 24^{\text{s}}$

Weather Conditions: Clear

Beginning and Ending Declination: $-2^\circ 50' 24''$
 $-3^\circ 08' 17''$ Temperature (outside): 18° Beginning and Ending Hour Angle: E $00^{\text{h}} 43^{\text{m}} 52^{\text{s}}$
W $00^{\text{h}} 43^{\text{m}} 35^{\text{s}}$ Temperature (radome): 61°

Time of Meridional Crossing: 0415 EST

Relative Humidity: 36%

Solar Declination: $-16^\circ 51' 53''$ Dew Point: -2° Solar Colongitude: 146° Declination of Center
(Dial Reading) $-3^\circ 02' 41''$ REMARKSDeclination error is $3' 20''$ South of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 3, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	84.0	89.4	89.0				
	Phase Angle	55	34	14				
	Latitude	-58	-48	-40				
	Longitude	E 06	E 27	E 47				
2	Antenna Temp.	82.3	92.9	97.5	99.8	95.6		
	Phase Angle	86	64	47	31	14		
	Latitude	-45	-36	-30	-23	-17		
	Longitude	W 25	W 03	E 14	E 30	E 47		
3	Antenna Temp.	81.0	95.6	104	107	107	105	91.9
	Phase Angle	116	87	70	55	20	24	02
	Latitude	-34	-27	-20	-15	-08	-03	+04
	Longitude	W 51	W 26	W 09	E 06	E 21	E 37	E 59
4	Antenna Temp.	83.0	96.7	105	108	108	104	89.4
	Phase Angle	113	92	75	61	46	30	09
	Latitude	-17	-12	-06	0	+06	+12	+17
	Longitude	W 52	W 31	W 14	0	E 15	E 31	E 52
5	Antenna Temp.	82.9	96.9	105	108	107	102	88.5
	Phase Angle	119	98	82	67	52	35	10
	Latitude	-04	+03	+08	+15	+21	+27	+33
	Longitude	W 58	W 37	W 21	W 06	E 09	E 26	E 51
6	Antenna Temp.	88.5	96.4	97.8	96.4	90.8		
	Phase Angle	108	90	73	48	37		
	Latitude	+17	+23	+30	+37	+47		
	Longitude	W 47	W 29	W 13	E 13	E 24		
7	Antenna Temp.	76.4	78.2	70.2				
	Phase Angle	107	88	67				
	Latitude	+40	+48	+58				
	Longitude	W 46	W 27	W 06				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date: February 4, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 74°

From 0415 EST To 0545 EST

Polar Axis Tilt Angle: 20.3°

Number of Scans: 7

Angular Size of Moon: 29' 46"

Beginning and Ending RA: 14^h 06^m 11^s
14^h 09^m 00^s

Weather Conditions: Light overcast

Beginning and Ending Declination: -7° 37' 18"
-7° 54' 02"

Temperature (outside): 18°

Beginning and Ending Hour Angle: E 00^h 41^m 20^s
W 00^h 46^m 43^s

Temperature (radome): 68°

Time of Meridional Crossing: 0500 EST

Relative Humidity: 60%

Solar Declination: -16° 34' 25"

Dew Point: 7°

Solar Colongitude: 159°

Declination of Center
(Dial Reading) -7° 51' 58"REMARKS

Declination error is 6' 17" South of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 4, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	77.5	85.0	84.0				
	Phase Angle	71	49	29				
	Latitude	-58	-49	-41				
	Longitude	E 03	E 25	E 45				
2	Antenna Temp.	83.1	92.6	98.5	99.6	98.1		
	Phase Angle	100	79	62	45	27		
	Latitude	-44	-36	-36	-24	-18		
	Longitude	W 26	W 05	E 12	E 29	E 47		
3	Antenna Temp.	77.2	89.3	101	106	107	105	93.3
	Phase Angle	126	101	84	68	53	37	15
	Latitude	-32	-26	-20	-15	-09	+04	+02
	Longitude	W 52	W 27	W 10	E 06	E 21	E 37	E 59
4	Antenna Temp.	76.4	89.5	96.1	101	100	96.6	90.1
	Phase Angle	126	105	89	74	59	43	22
	Latitude	-17	-11	-06	0	+05	+11	+17
	Longitude	W 52	W 31	W 15	0	E 15	E 31	E 52
5	Antenna Temp.	75.3	89.4	96.5	100	102	100	83.8
	Phase Angle	133	111	95	79	64	46	23
	Latitude	-02	+04	+09	+15	+20	+26	+32
	Longitude	W 59	W 37	W 21	W 05	E 10	E 28	E 51
6	Antenna Temp.	84.4	88.9	90.5	88.9	83.4		
	Phase Angle	121	103	86	69	48		
	Latitude	+18	+25	+30	+37	+44		
	Longitude	W 47	W 29	W 12	E 05	E 26		
7	Antenna Temp.	70.4	74.6	66.8				
	Phase Angle	119	100	77				
	Latitude	+42	+49	+58				
	Longitude	W 45	W 26	W 03				

DAILY REPORT
LUNAR OBSERVING PROGRAM
CONTRACT NO. NASw-593

Date: February 5, 1964	Observer: N. Guido
Time of Observation:	Lunar Phase: 87°
From 0500 EST To 0630 EST	Polar Axis Tilt Angle: 17.4°
Number of Scans: 7	Angular Size of Moon: $29' 37''$
Beginning and Ending RA: $14^{\text{h}} 52^{\text{m}} 59^{\text{s}}$ $14^{\text{h}} 55^{\text{m}} 51^{\text{s}}$	Weather Conditions: Cloudy
Beginning and Ending Declination: $-12^\circ 00' 58''$ $-12^\circ 15' 59''$	Temperature (outside): 39°
Beginning and Ending Hour Angle: E $00^{\text{h}} 39^{\text{m}} 05^{\text{s}}$ W $00^{\text{h}} 48^{\text{m}} 20^{\text{s}}$	Temperature (radome): 73°
Time of Meridional Crossing: 0545 EST	Relative Humidity: 51%
Solar Declination: $-16^\circ 16' 40''$	Dew Point: 23°
Solar Colongitude: 171°	Declination of Center (Dial Reading) $-12^\circ 15' 50''$

REMARKS

Declination error is 7' 21" South of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 5, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	50.7	66.6	67.6				
	Phase Angle	91	66	45				
	Latitude	-58	-51	-45				
	Longitude	W 04	E 21	E 42				
2	Antenna Temp.	70.4	77.4	83.1	86.2	83.1		
	Phase Angle	117	95	77	60	41		
	Latitude	-42	-36	-31	-26	-21		
	Longitude	W 30	W 08	E 10	E 27	E 46		
3	Antenna Temp.	71.7	85.5	93.6	96.4	96.8	96.4	87.8
	Phase Angle	141	116	99	83	68	51	28
	Latitude	-28	-24	-19	-15	-11	-07	-03
	Longitude	W 54	W 29	W 12	E 04	E 19	E 36	E 59
4	Antenna Temp.	75.8	84.9	90.6	94.9	95.8	94.5	87.7
	Phase Angle	140	118	102	87	72	56	34
	Latitude	-13	-09	-04	0	+05	+09	+13
	Longitude	W 53	W 31	W 15	0	E 15	E 31	E 53
5	Antenna Temp.	73.1	87.3	93.6	95.9	96.4	94.0	81.2
	Phase Angle	146	124	107	92	76	58	34
	Latitude	+02	+06	+11	+15	+20	+24	+29
	Longitude	W 59	W 37	W 20	W 05	E 11	E 29	E 53
6	Antenna Temp.	79.0	86.7	88.2	88.2	80.4		
	Phase Angle	133	114	97	79	57		
	Latitude	+22	+26	+31	+36	+42		
	Longitude	W 46	W 27	W 10	E 08	E 30		
7	Antenna Temp.	53.8	59.5	56.2				
	Phase Angle	129	108	83				
	Latitude	+45	+51	+59				
	Longitude	W 42	W 21	E 04				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date: February 6, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 99°

From 0545 EST To 0715 EST

Polar Axis Tilt Angle: 13.8°

Number of Scans: 7

Angular Size of Moon: 29' 32"

Beginning and Ending RA: 15^h 40^m 47^s
15^h 43^m 44^s

Weather Conditions: Clear

Beginning and Ending Declination: -15° 52' 33"
-16° 05' 22"

Temperature (outside): 28°

Beginning and Ending Hour Angle: E 00^h 37^m 47^s
W 00^h 49^m 33^s

Temperature (radome): 79°

Time of Meridional Crossing: 0630 EST

Relative Humidity: 94%

Solar Declination: -15° 58' 38"

Dew Point: 27°

Solar Colongitude: 183°

Declination of Center
(Dial Reading) -16° 07' 53"

REMARKS

Declination error is 8' 54" South of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 6, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	74.0	82.0	84.0				
	Phase Angle	105	80	57				
	Latitude	-58	-51	-45				
	Longitude	W 06	E 19	E 42				
2	Antenna Temp.	79.9	89.7	95.6	97.0	97.5		
	Phase Angle	129	107	90	72	53		
	Latitude	-41	-36	-32	-27	-23		
	Longitude	W 30	W 08	E 09	E 27	E 46		
3	Antenna Temp.	79.5	91.1	99.1	103	104	104	95.4
	Phase Angle	153	128	111	95	79	63	40
	Latitude	-27	-24	-19	-15	-11	-07	-04
	Longitude	W 54	W 29	W 12	E 04	E 20	E 36	E 59
4	Antenna Temp.	81.9	92.5	98.5	102	102	101	96.4
	Phase Angle	152	131	114	99	84	67	46
	Latitude	-13	-08	-04	0	+04	+08	+12
	Longitude	W 53	W 32	W 15	0	E 15	E 32	E 53
5	Antenna Temp.	76.7	89.8	95.6	98.2	99.2	98.8	89.3
	Phase Angle	157	136	119	103	87	69	45
	Latitude	+03	+07	+12	+15	+19	+24	+28
	Longitude	W 58	W 37	W 20	W 04	E 12	E 30	E 54
6	Antenna Temp.	82.9	88.8	91.0	91.0	88.4		
	Phase Angle	144	126	108	90	69		
	Latitude	+23	+27	+32	+37	+42		
	Longitude	W 45	W 27	W 09	E 09	E 30		
7	Antenna Temp.	62.4	66.3	64.1				
	Phase Angle	140	118	93				
	Latitude	+45	+52	+58				
	Longitude	W 41	W 19	E 06				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date: February 10, 1964

Observers: N. Guido

Time of Observation:

Lunar Phase: 149°

From 0845 EST To 1015 EST

Polar Axis Tilt Angle: 354.5°

Number of Scans: 7

Angular Size of Moon: 29' 51"

Beginning and Ending RA: 19^h 09^m 42^s
19^h 13^m 04^s

Weather Conditions: Overcast

Beginning and Ending Declination: -22° 57' 30"
-22° 56' 00"

Temperature (outside): 16°

Beginning and Ending Hour Angle: E 00^h 49^m 41^s
W 00^h 37^m 14^s

Temperature (radome): 77°

Time of Meridional Crossing: 0930 EST

Relative Humidity: 48%

Solar Declination: -14° 43' 49"

Dew Point: 1°

Solar Colongitude: 231.9°

Declination of Center
(Dial Reading) -23° 08' 37"

REMARKS

Declination error is 11' 50" South of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 10, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	71.7	73.2	71.7				
	Phase Angle	182	157	129				
	Latitude	-51	-54	-56				
	Longitude	W 33	W 08	E 20				
2	Antenna Temp.	75.7	80.1	82.1	81.6	79.1		
	Phase Angle	192	171	153	134	113		
	Latitude	-28	-30	-33	-35	-36		
	Longitude	W 43	W 22	W 04	E 15	E 36		
3	Antenna Temp.	73.7	80.8	86.5	89.5	88.9	88.0	81.8
	Phase Angle	207	184	167	151	134	117	95
	Latitude	-10	-13	-14	-15	-16	-18	-20
	Longitude	W 58	W 35	W 18	W 02	E 15	E 32	E 54
4	Antenna Temp.	72.5	81.6	87.2	89.1	89.1	87.2	83.6
	Phase Angle	203	181	165	149	133	116	95
	Latitude	+05	+04	+02	0	-02	-04	-05
	Longitude	W 54	W 32	W 16	0	E 16	E 33	E 54
5	Antenna Temp.	68.0	78.5	83.4	87.0	88.0	85.5	79.4
	Phase Angle	205	181	163	147	131	114	91
	Latitude	+21	+19	+17	+16	+14	+13	+11
	Longitude	W 56	W 32	W 14	E 02	E 18	E 35	E 58
6	Antenna Temp.	70.9	76.4	79.4	80.0	77.5		
	Phase Angle	185	156	145	127	107		
	Latitude	+36	+35	+33	+31	+29		
	Longitude	W 36	W 15	E 04	E 22	E 42		
7	Antenna Temp.	59.5	65.0	64.4				
	Phase Angle	160	141	115				
	Latitude	+56	+53	+51				
	Longitude	W 19	E 08	E 34				

DAILY REPORT
LUNAR OBSERVING PROGRAM
CONTRACT NO. NASw-593

Date: February 11, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 161°

From 0945 EST To 1115 EST

Polar Axis Tilt Angle: 349.4°

Number of Scans: 7

Angular Size of Moon: $30' 06''$

Beginning and Ending RA: $20^{\text{h}} 05^{\text{m}} 58^{\text{s}}$
 $20^{\text{h}} 09^{\text{m}} 21^{\text{s}}$

Weather Conditions: Cloudy, fore-
cast for snow in the afternoon.

Beginning and Ending Declination: $-21^{\circ} 57' 21''$
 $-21^{\circ} 51' 21''$

Temperature (outside): 21°

Beginning and Ending Hour Angle: $E 00^{\text{h}} 41^{\text{m}} 35^{\text{s}}$
 $W 00^{\text{h}} 45^{\text{m}} 19^{\text{s}}$

Temperature (radome): 79°

Time of Meridional Crossing: 1030 EST

Relative Humidity: 48%

Solar Declination: $-14^{\circ} 24' 29''$

Dew Point: 6°

Solar Colongitude: 244°

Declination of Center
(Dial Reading) $-22^{\circ} 06' 08''$

REMARKS

Declination error is $11' 45''$ South of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 11, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	72.2	72.8	71.2				
	Phase Angle	175	148	123				
	Latitude	-57	-53	-48				
	Longitude	W 14	E 13	E 38				
2	Antenna Temp.	79.8	85.0	86.0	82.9	80.8		
	Phase Angle	195	173	155	137	117		
	Latitude	-38	-35	-32	-29	-26		
	Longitude	W 34	W 12	E 06	E 24	E 44		
3	Antenna Temp.	75.4	84.8	90.0	91.2	91.2	88.5	84.8
	Phase Angle	216	193	175	158	143	125	103
	Latitude	-24	-21	-18	-16	-13	-10	-07
	Longitude	W 55	W 32	W 14	E 03	E 18	E 36	E 58
4	Antenna Temp.	74.8	83.0	87.7	89.8	89.3	84.6	81.0
	Phase Angle	215	193	177	161	145	129	107
	Latitude	-08	-05	-03	0	+03	+05	+08
	Longitude	W 54	W 32	W 16	0	E 16	E 32	E 54
5	Antenna Temp.	71.8	82.0	86.6	88.1	88.6	87.1	80.5
	Phase Angle	219	197	179	164	148	129	106
	Latitude	+07	+10	+13	+16	+18	+21	+24
	Longitude	W 58	W 36	W 18	W 03	E 13	E 32	E 55
6	Antenna Temp.	73.3	78.6	82.2	81.7	79.1		
	Phase Angle	205	185	167	149	127		
	Latitude	+26	+29	+32	+35	+38		
	Longitude	W 44	W 24	W 06	E 12	E 34		
7	Antenna Temp.	61.3	65.0	62.8				
	Phase Angle	198	174	148				
	Latitude	+49	+53	+57				
	Longitude	W 37	W 13	E 13				

DAILY REPORT
LUNAR OBSERVING PROGRAM
CONTRACT NO. NASw-593

Date: February 12, 1964 Observer: N. Guido

From 1030 EST To 1200 EST

Polar Axis Tilt Angle: 344.8°

Number of Scans: 7

Angular Size of Moon: $30^{\circ} 42''$

Beginning and Ending RA: $21^{\text{h}} 01^{\text{m}} 40^{\text{s}}$
 $21^{\text{h}} 05^{\text{m}} 02^{\text{s}}$

Weather Conditions: Clear

Beginning and Ending Declination: $-19^{\circ} 44' 46''$
 $-19^{\circ} 34' 29''$

Temperature (outside): 36°

Beginning and Ending Hour Angle: E 00^h 49^m 02^s
W 00^h 37^m 48^s

Temperature (radome): 77°

Time of Meridional Crossing: 1115 EST

Relative Humidity: 38%

Solar Declination: $-14^{\circ} 04' 54''$

Dew Point: 15°

Solar Colongitude : 256.3°

Declination of Center
(Dial Reading) $-19^{\circ} 51' 45''$

REMARKS

Declination error is 12' 06" South of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 12, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	70.2	67.6	64.0				
	Phase Angle	216	194	169				
	Latitude	-45	-51	-58				
	Longitude	W 42	W 20	E 05				
2	Antenna Temp.	79.7	85.1	85.1	83.4	79.2		
	Phase Angle	219	201	183	166	144		
	Latitude	-22	-26	-31	-36	-41		
	Longitude	W 45	W 27	W 09	E 08	E 30		
3	Antenna Temp.	76.3	85.3	90.1	91.6	90.1	89.5	81.6
	Phase Angle	233	211	194	178	163	145	120
	Latitude	-03	-07	-11	-15	-19	-24	-28
	Longitude	W 59	W 37	W 20	W 04	E 11	E 29	E 54
4	Antenna Temp.	72.5	81.3	84.4	85.9	85.0	82.9	77.7
	Phase Angle	227	206	189	174	159	142	121
	Latitude	+13	+08	+04	0	-04	-08	-12
	Longitude	W 53	W 32	W 15	0	E 15	E 32	E 53
5	Antenna Temp.	70.4	82.5	86.2	90.4	88.8	86.7	80.4
	Phase Angle	228	203	185	170	154	137	115
	Latitude	+28	+24	+19	+15	+11	+07	+03
	Longitude	W 54	W 29	W 11	E 04	E 20	E 37	E 59
6	Antenna Temp.	69.7	76.4	78.4	79.9	76.4		
	Phase Angle	204	182	165	144	129		
	Latitude	+41	+36	+31	+26	+22		
	Longitude	W 30	W 08	E 09	E 27	E 45		
7	Antenna Temp.	56.3	62.6	58.4				
	Phase Angle	179	154	133				
	Latitude	+58	+51	+45				
	Longitude	W 05	E 20	E 41				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date: February 13, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 186°

From 1130 EST to 1300 EST

Polar Axis Tilt Angle: 340.9°

Number of Scans: 7

Angular Size of Moon: $31' 01''$

Beginning and Ending RA: $21^{\text{h}} 57^{\text{m}} 14^{\text{s}}$
 $22^{\text{h}} 00^{\text{m}} 32^{\text{s}}$

Weather Conditions: Overcast,
forecast snow and rain.

Beginning and Ending Declination: $-16^{\circ} 22' 22''$
 $-16^{\circ} 08' 15''$

Temperature (outside): 45°

Beginning and Ending Hour Angle: E $00^{\text{h}} 40^{\text{m}} 27^{\text{s}}$
W $00^{\text{h}} 46^{\text{m}} 23^{\text{s}}$

Temperature (radome): 77°

Time of Meridional Crossing: 1215 EST

Relative Humidity: 31%

Solar Declination: $-13^{\circ} 45' 05''$

Dew Point: 18°

Solar Colongitude: 268.5°

Declination of Center
(Dial Reading) $-16^{\circ} 26' 18''$

REMARKS

Declination error is $10' 58''$ South of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 13, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	73.3	73.3	70.3				
	Phase Angle	231	210	188				
	Latitude	-43	-50	-59				
	Longitude	W 45	W 24	W 02				
2	Antenna Temp.	74.3	80.1	81.6	79.1	78.2		
	Phase Angle	233	215	198	181	159		
	Latitude	-19	-25	-30	-37	-43		
	Longitude	W 47	W 29	W 12	E 05	E 27		
3	Antenna Temp.	69.4	81.3	85.3	85.3	84.3	82.8	77.8
	Phase Angle	245	223	206	191	176	158	134
	Latitude	+01	-04	-09	-15	-20	-26	-32
	Longitude	W 59	W 37	W 20	W 05	E 10	E 28	E 52
4	Antenna Temp.	77.6	86.4	90.5	93.1	92.0	90.0	82.8
	Phase Angle	238	217	201	186	171	155	134
	Latitude	+16	+10	+5	0	-05	-10	-16
	Longitude	W 52	W 31	W 15	0	E 15	E 31	E 52
5	Antenna Temp.	66.2	77.5	82.6	84.6	83.1	81.6	73.4
	Phase Angle	238	214	196	181	166	149	127
	Latitude	+32	+26	+20	+15	+10	+04	-01
	Longitude	W 52	W 28	W 10	E 05	E 20	E 37	E 59
6	Antenna Temp.	69.3	73.5	74.6	75.6	75.1		
	Phase Angle	213	191	174	157	139		
	Latitude	+43	+37	+31	+25	+20		
	Longitude	W 27	W 05	E 12	E 29	E 47		
7	Antenna Temp.	54.9	60.1	55.4				
	Phase Angle	185	162	141				
	Latitude	+59	+50	+43				
	Longitude	E 01	E 24	E 45				

DAILY REPORT
LUNAR OBSERVING PROGRAM
CONTRACT NO. NASw-593

Date: February 15, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 218°

From 1300 EST to 1430 EST

Polar Axis Tilt Angle: 336.4°

Number of Scans: 7

Angular Size of Moon: 31' 35"

Beginning and Ending RA: 23^h 44^m 17^s
23^h 47^m 29^s

Weather Conditions: Clear

Beginning and Ending Declination: -7° 03' 30"
-6° 44' 13"

Temperature (outside): 38°

Beginning and Ending Hour Angle: E 00^h 49^m 18^s
W 00^h 39^m 47^s

Temperature (radome): 80°

Time of Meridional Crossing: 1345 EST

Relative Humidity: 50%

Solar Declination: -13° 04' 46"

Dew Point: 22°

Solar Colongitude: 292.9°

Declination of Center
(Dial Reading) -7° 01' 09"

REMARKS

Declination error is 7' 17" South of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 15, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	74.3	73.3	70.4				
	Phase Angle	266	247	228				
	Latitude	-38	-47	-58				
	Longitude	W 48	W 29	W 10				
2	Antenna Temp.	78.0	82.3	83.7	80.9	76.6		
	Phase Angle	266	248	233	216	195		
	Latitude	-16	-22	-29	-37	-45		
	Longitude	W 48	W 30	W 15	E 02	E 23		
3	Antenna Temp.	70.4	77.0	82.7	85.6	84.2	81.3	75.7
	Phase Angle	277	255	239	225	210	193	168
	Latitude	+05	-01	-08	-14	-21	-28	-36
	Longitude	W 59	W 37	W 21	W 07	E 08	E 25	E 50
4	Antenna Temp.	68.4	78.3	84.6	86.4	84.0	80.7	68.8
	Phase Angle	269	248	232	218	204	188	167
	Latitude	+19	+13	+06	0	-06	-13	-19
	Longitude	W 51	W 30	W 14	0	E 14	E 30	E 51
5	Antenna Temp.	66.2	77.0	83.5	85.8	84.9	81.0	75.5
	Phase Angle	268	244	226	212	197	181	159
	Latitude	+36	+28	+21	+14	+08	+02	-05
	Longitude	W 50	W 26	W 08	E 06	E 21	E 37	E 59
6	Antenna Temp.	69.4	76.6	77.7	79.2	76.6		
	Phase Angle	240	220	203	188	170		
	Latitude	+45	+37	+30	+23	+16		
	Longitude	W 22	W 02	E 15	E 30	E 48		
7	Antenna Temp.	63.1	70.2	67.6				
	Phase Angle	209	189	170				
	Latitude	+58	+47	+39				
	Longitude	E 09	E 29	E 48				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date: February 17, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 237°

From 1445 EST to 1615 EST

Polar Axis Tilt Angle: 337°

Number of Scans: 7

Angular Size of Moon: $31' 59''$

Beginning and Ending RA: $1^{\text{h}} 30^{\text{m}} 17^{\text{s}}$
 $1^{\text{h}} 33^{\text{m}} 31^{\text{s}}$

Weather Conditions: Clear

Beginning and Ending Declination: $+4^{\circ} 03' 39''$
 $+4^{\circ} 23' 53''$

Temperature (outside): 30°

Beginning and Ending Hour Angle: E $00^{\text{h}} 42^{\text{m}} 03^{\text{s}}$
W $00^{\text{h}} 45^{\text{m}} 01^{\text{s}}$

Temperature (radome): 72°

Time of Meridional Crossing 1530 EST

Relative Humidity: 46%

Solar Declination: $-12^{\circ} 23' 37''$

Dew Point: 14°

Solar Colongitude: 317°

Declination of Center
(Dial Reading) $+4^{\circ} 13' 31''$

REMARKS

Declination error is $0' 15''$ South of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 17, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.							
	Phase Angle	283	265	243				
	Latitude	-40	-48	-58				
	Longitude	W 46	W 28	W 06				
2	Antenna Temp.	76.3	80.5	82.0	79.2	73.6		
	Phase Angle	284	267	251	234	212		
	Latitude	-17	-23	-30	-37	-45		
	Longitude	W 47	W 30	W 14	E 03	E 25		
3	Antenna Temp.	70.7	75.8	80.1	82.4	81.5	78.2	73.0
	Phase Angle	296	274	258	243	228	211	187
	Latitude	+04	-02	-08	-14	-20	-26	-34
	Longitude	W 59	W 37	W 21	W 06	E 09	E 26	E 50
4	Antenna Temp.	73.9	79.6	82.4	84.8	83.8	80.5	76.3
	Phase Angle	289	268	252	237	222	206	185
	Latitude	+18	+12	+06	0	-06	-12	-18
	Longitude	W 52	W 31	W 15	0	E 15	E 31	E 52
5	Antenna Temp.	52.3	65.5	71.6	75.8	73.9	67.8	50.4
	Phase Angle	287	263	246	231	216	200	178
	Latitude	+34	+27	+21	+15	+08	+02	-04
	Longitude	W 50	W 26	W 09	E 06	E 21	E 37	E 59
6	Antenna Temp.	65.0	71.7	73.7	73.7	70.3		
	Phase Angle	261	240	223	207	189		
	Latitude	+45	+37	+30	+23	+17		
	Longitude	W 24	W 03	E 14	E 30	E 48		
7	Antenna Temp.	49.2	55.5	53.6				
	Phase Angle	229	209	189				
	Latitude	+58	+48	+40				
	Longitude	E 08	E 28	E 48				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date: February 18, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 250°

From 1530 EST to 1700 EST

Polar Axis Tilt Angle: 339°

Number of Scans: 7

Angular Size of Moon: $32' 07''$ Beginning and Ending RA: $2^h 24^m 16^s$
 $2^h 27^m 35^s$

Weather Conditions: High Overcast

Beginning and Ending Declination: $+9^\circ 29' 12''$
 $+9^\circ 48' 10''$ Temperature (outside): 37° Beginning and Ending Hour Angle: E $00^h 46^m 55^s$
W $00^h 40^m 02^s$ Temperature (radome): 78°

Time of Meridional Crossing: 1615 EST

Relative Humidity: 53%

Solar Declination: $-12^\circ 02' 44''$ Dew Point: 22° Solar Colongitude: 329.5° Declination of Center
(Dial Reading) $+9^\circ 40' 35''$ REMARKSDeclination error is $1' 53''$ North of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 18, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	69.7	68.8	65.3				
	Phase Angle	296	276	254				
	Latitude	-41	-49	-58				
	Longitude	W 46	W 26	W 04				
2	Antenna Temp.	78.8	81.8	81.0	78.4	73.9		
	Phase Angle	297	279	263	246	224		
	Latitude	-18	-24	-30	-36	-44		
	Longitude	W 47	W 29	W 13	E 04	E 26		
3	Antenna Temp.	77.5	81.1	83.3	84.7	84.1	79.3	75.7
	Phase Angle	309	287	271	256	241	223	199
	Latitude	+03	-03	-09	-15	-20	-27	-33
	Longitude	W 59	W 37	W 21	W 06	E 09	E 27	E 51
4	Antenna Temp.	73.7	78.3	80.9	82.2	80.8	78.7	74.2
	Phase Angle	302	281	265	250	236	219	198
	Latitude	+17	+11	+05	0	-06	-11	-17
	Longitude	W 52	W 31	W 15	0	E 14	E 31	E 52
5	Antenna Temp.	73.6	79.6	81.1	82.9	82.9	79.7	76.6
	Phase Angle	301	277	259	244	229	213	191
	Latitude	+33	+26	+21	+15	+09	+04	-03
	Longitude	W 51	W 27	W 09	E 06	E 21	E 37	E 59
6	Antenna Temp.	70.4	75.0	76.4	75.4	73.1		
	Phase Angle	275	254	237	221	204		
	Latitude	+44	+37	+30	+24	+18		
	Longitude	W 25	W 04	E 13	E 29	E 46		
7	Antenna Temp.	63.0	67.1	67.1				
	Phase Angle	246	224	205				
	Latitude	+58	+49	+41				
	Longitude	E 04	E 26	E 45				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date:	February 21, 1964	Observer:	N. Guido
Time of Observation:		Lunar Phase:	288°
	From 1815 EST to 1945 EST	Polar Axis Tilt Angle:	357.7°
Number of Scans:	7	Angular Size of Moon:	32' 26"
Beginning and Ending RA:	$5^{\text{h}} 20^{\text{m}} 39^{\text{s}}$ $5^{\text{h}} 24^{\text{m}} 25^{\text{s}}$	Weather Conditions:	Overcast
Beginning and Ending Declination:	$+21^{\circ} 27' 05''$ $+21^{\circ} 34' 59''$	Temperature (outside):	26°
Beginning and Ending Hour Angle:	E $00^{\text{h}} 45^{\text{m}} 55^{\text{s}}$ W $00^{\text{h}} 40^{\text{m}} 37^{\text{s}}$	Temperature (radome):	77°
Time of Meridional Crossing:	1900 EST	Relative Humidity:	51%
Solar Declination:	$-10^{\circ} 58' 59''$	Dew Point:	12°
Solar Colongitude:	18.2°	Declination of Center (Dial Reading)	$+21^{\circ} 41' 20''$

REMARKS

Declination error is 10' 15" North of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 21, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	75.0	72.1	67.1				
	Phase Angle	318	291	263				
	Latitude	-53	-54	-55				
	Longitude	W 30	W 03	E 25				
2	Antenna Temp.	87.4	86.9	82.8	77.7	73.5		
	Phase Angle	328	308	290	271	249		
	Latitude	-31	-32	-32	-33	-34		
	Longitude	W 40	W 20	W 02	E 17	E 39		
3	Antenna Temp.	90.7	93.5	92.5	88.8	84.1	78.8	73.1
	Phase Angle	346	323	305	289	272	255	231
	Latitude	-14	-15	-15	-16	-16	-17	-17
	Longitude	W 58	W 35	W 17	W 01	E 16	E 33	E 57
4	Antenna Temp.	90.9	95.1	92.7	90.5	85.4	80.4	73.9
	Phase Angle	342	320	304	288	272	256	234
	Latitude	+02	+02	+01	0	-01	-02	-02
	Longitude	W 54	W 32	W 16	0	E 16	E 32	E 54
5	Antenna Temp.	88.3	93.9	92.1	89.3	84.7	80.9	75.9
	Phase Angle	346	321	304	287	271	253	230
	Latitude	+17	+17	+16	+15	+15	+14	+14
	Longitude	W 58	W 33	W 16	E 01	E 17	E 35	E 58
6	Antenna Temp.	85.6	83.8	82.0	79.3	73.0		
	Phase Angle	326	305	286	268	247		
	Latitude	+34	+34	+33	+32	+31		
	Longitude	W 38	W 17	E 02	E 20	E 41		
7	Antenna Temp.	75.9	71.9	68.8				
	Phase Angle	312	285	258				
	Latitude	+55	+54	+53				
	Longitude	W 24	E 03	E 30				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date: February 22, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 300°

From 1915 EST to 2045 EST

Polar Axis Tilt Angle: 3.8°

Number of Scans: 7

Angular Size of Moon: 32' 13"

Beginning and Ending RA: 6^h 24^m 00^s
6^h 27^m 49^s

Weather Conditions: Clear

Beginning and Ending Declination: +22° 56' 02"
+22° 58' 22"

Temperature (outside): 21°

Beginning and Ending Hour Angle: E 00^h 45^m 06^s
W 00^h 41^m 21^s

Temperature (radome): 73°

Time of Meridional Crossing: 2000 EST

Relative Humidity: 56%

Solar Declination: -10° 37' 23"

Dew Point: 9°

Solar Colongitude: 30°

Declination of Center
(Dial Reading) +23° 09' 06"REMARKS

Declination error is 11' 50" North of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 22, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	76.1	73.0	67.6				
	Phase Angle	323	296	270				
	Latitude	-55	-53	-52				
	Longitude	W 23	E 04	E 30				
2	Antenna Temp.	86.3	88.2	84.6	79.1	73.6		
	Phase Angle	338	317	298	279	259		
	Latitude	-34	-33	-32	-31	-30		
	Longitude	W 38	W 17	E 02	E 21	E 41		
3	Antenna Temp.	88.8	94.8	94.8	90.7	86.1	78.8	72.9
	Phase Angle	357	333	315	299	283	265	242
	Latitude	-18	-17	-16	-15	-14	-14	-13
	Longitude	W 57	W 33	W 15	E 01	E 17	E 35	E 58
4	Antenna Temp.	91.0	95.7	94.1	90.5	86.4	78.3	72.9
	Phase Angle	354	332	316	300	284	268	246
	Latitude	-02	-01	-01	0	+01	+01	+02
	Longitude	W 54	W 32	W 16	0	E 16	E 32	E 54
5	Antenna Temp.	91.8	97.3	96.3	93.6	86.9	80.1	75.1
	Phase Angle	358	334	317	301	284	267	243
	Latitude	+13	+14	+15	+16	+16	+17	+18
	Longitude	W 58	W 34	W 17	W 01	E 16	E 33	E 57
6	Antenna Temp.	88.8	89.2	87.0	81.1	73.9		
	Phase Angle	341	320	302	283	262		
	Latitude	+31	+32	+33	+34	+35		
	Longitude	W 41	W 20	W 02	E 17	E 38		
7	Antenna Temp.	80.1	73.9	68.1				
	Phase Angle	330	304	277				
	Latitude	+53	+54	+55				
	Longitude	W 30	W 04	E 23				

DAILY REPORT

LUNAR OBSERVING PROGRAM

CONTRACT NO. NASw-593

Date: February 23, 1964

Observer: N. Guido

Time of Observation:

Lunar Phase: 313°

From 2015 EST to 2145 EST

Polar Axis Tilt Angle: 9.7°

Number of Scans: 7

Angular Size of Moon: 32' 06"

Beginning and Ending RA: 7^h 27^m 45^s

Weather Conditions: Clear

7^h 31^m 33^s

Beginning and Ending Declination: +22° 49' 55"

Temperature (outside): 26°

+22° 45' 56"

Beginning and Ending Hour Angle: E 00^h 44^m 57^s

Temperature (radome): 81°

W 00^h 41^m 32^s

Time of Meridional Crossing: 2100 EST

Relative Humidity: 51%

Solar Declination: -10° 15' 38"

Dew Point: 12°

Solar Colongitude: 43.5°

Declination of Center
(Dial Reading) +23° 00' 01"

REMARKS

Declination error is 11' 44" North of Ephemeris reading.

LUNAR OBSERVATIONAL DATA

Date: February 23, 1964

SCAN		A	B	C	D	E	F	G
1	Antenna Temp.	76.5	75.3	69.5				
	Phase Angle	327	301	276				
	Latitude	-56	-52	-48				
	Longitude	W 14	E 12	E 37				
2	Antenna Temp.	88.5	92.4	88.9	84.1	77.1		
	Phase Angle	347	325	307	289	269		
	Latitude	-38	-35	-32	-29	-26		
	Longitude	W 34	W 12	E 06	E 24	E 44		
3	Antenna Temp.	91.7	99.4	100	97.2	92.2	82.8	75.7
	Phase Angle	08	345	326	310	295	277	254
	Latitude	-23	-21	-17	-15	-13	-10	-07
	Longitude	W 55	W 32	W 13	E 03	E 18	E 36	E 59
4	Antenna Temp.	97.4	101	100	97.4	92.9	86.2	76.9
	Phase Angle	07	345	328	313	297	281	259
	Latitude	-07	-05	-03	0	+03	+05	+07
	Longitude	W 54	W 32	W 15	0	E 16	E 32	E 54
5	Antenna Temp.	94.4	79.8	101	97.9	92.2	83.9	76.0
	Phase Angle	11	348	331	316	299	282	257
	Latitude	+08	+11	+14	+16	+18	+21	+23
	Longitude	W 58	W 35	W 18	W 03	E 14	E 31	E 56
6	Antenna Temp.	97.1	97.1	94.4	89.1	79.9		
	Phase Angle	356	337	319	301	279		
	Latitude	+26	+29	+33	+36	+38		
	Longitude	W 43	W 24	W 06	E 12	E 34		
7	Antenna Temp.	85.6	81.7	77.6				
	Phase Angle	350	325	299				
	Latitude	+49	+53	+57				
	Longitude	W 37	W 12	E 14				